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UPPER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY. APPENDIX X--ETC(U)
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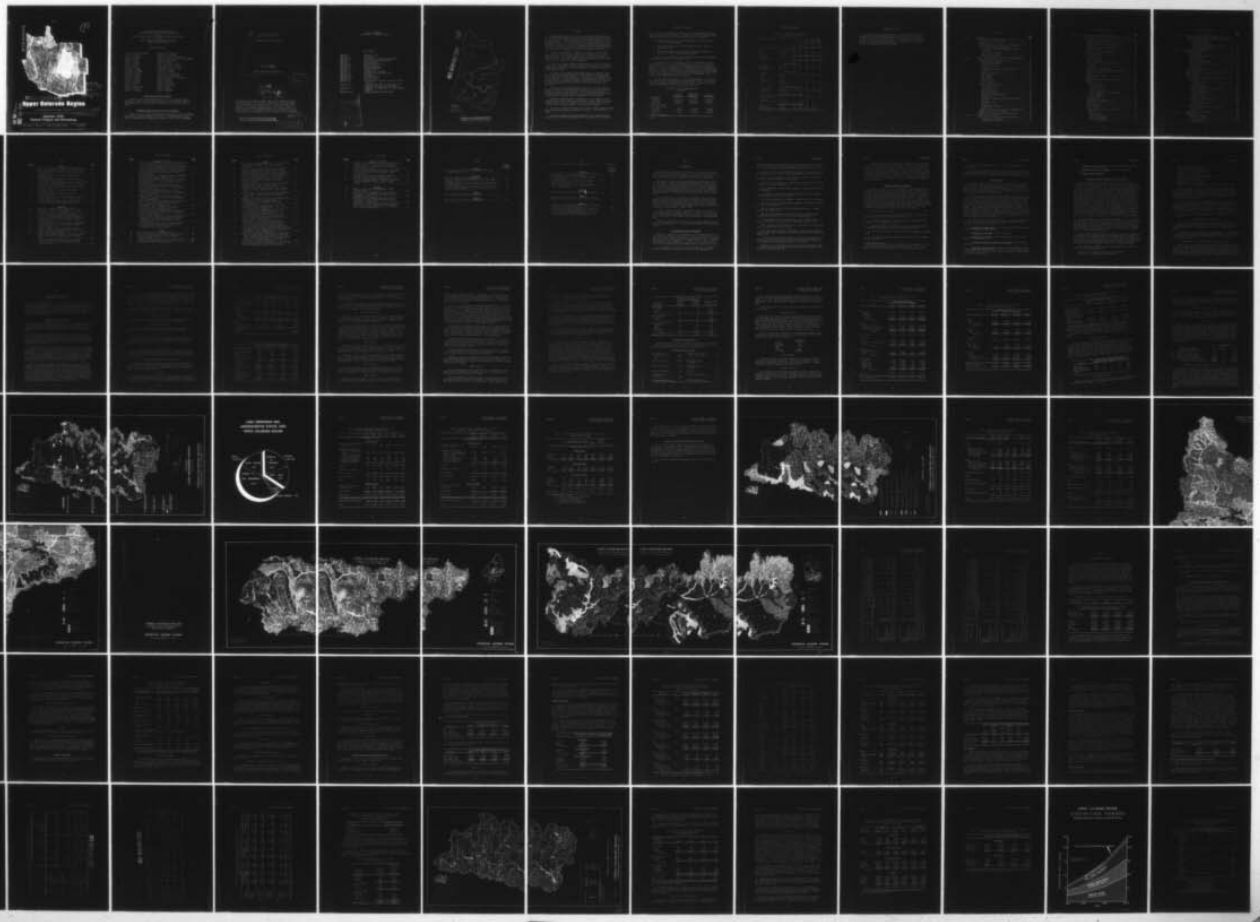

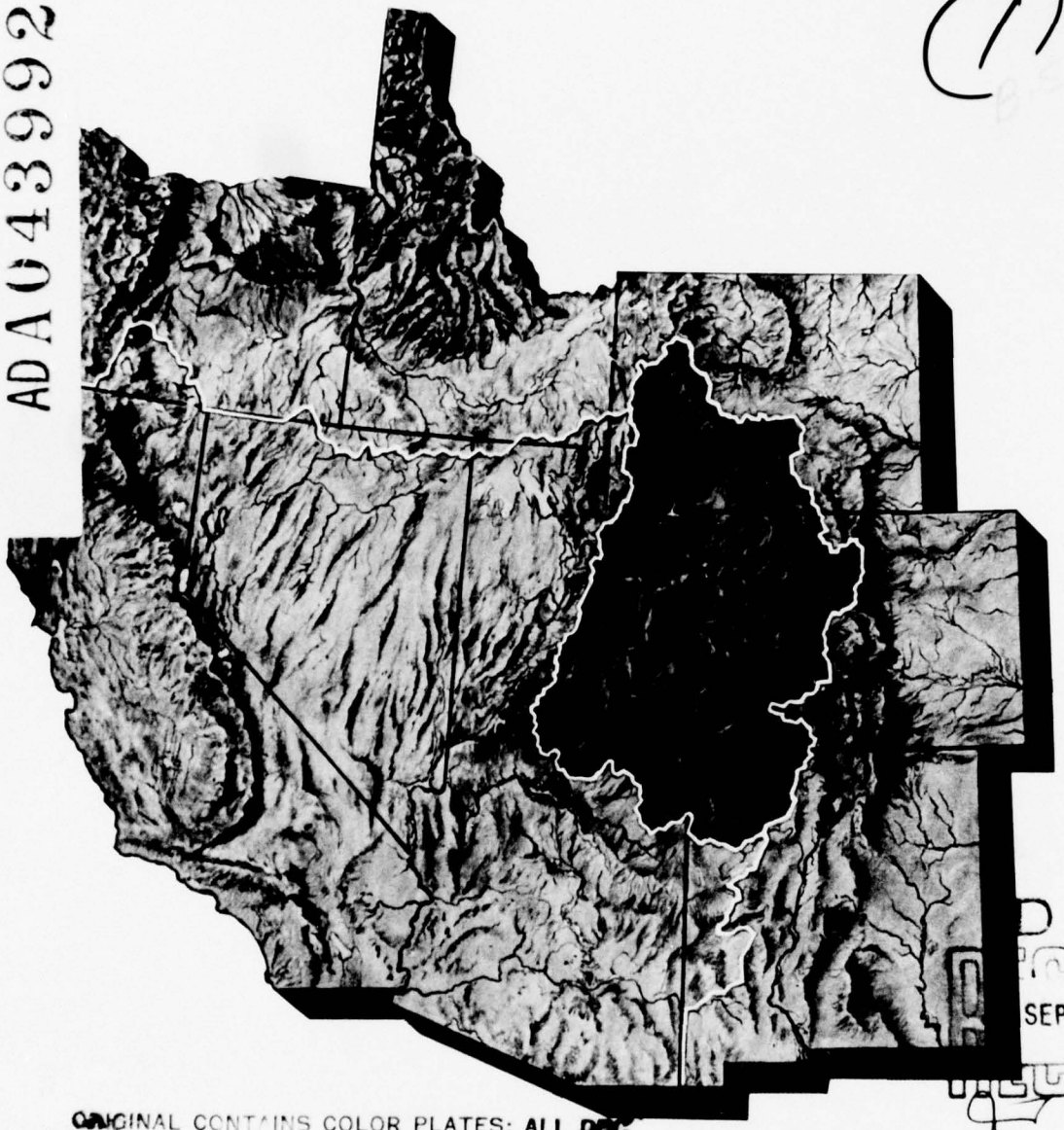

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE

Upper Colorado Region

Comprehensive Framework Study

Appendix XVIII
General Program and Alternatives

Upper Colorado Region State-Federal Inter-Agency Group / Pacific Southwest
Inter-Agency Committee / Water Resources Council

June 1971

This appendix was prepared by the
GENERAL PROGRAM AND ALTERNATIVES WORK GROUP
of the
UPPER COLORADO REGION STATE-FEDERAL INTER-AGENCY GROUP
for the
PACIFIC SOUTHWEST INTER-AGENCY COMMITTEE
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(6)

UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

APPENDIX XVIII

GENERAL PROGRAM AND ALTERNATIVES

(11) June 1971

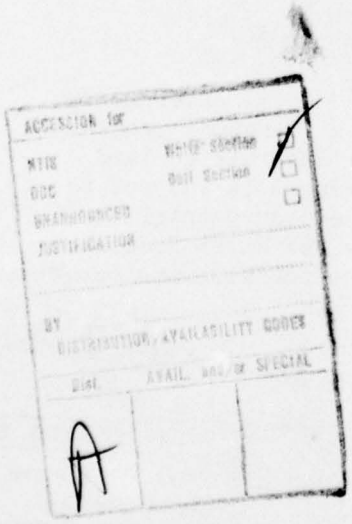
(12) 203p.

This report of the Upper Colorado Region State-Federal Interagency Group was prepared at field level and presents a framework program for the development and management of the water and related land resources of the Upper Colorado Region. This report is subject to review by the interested Federal agencies at the departmental level, by the Governors of the affected states, and by the Water Resources Council prior to its transmittal to the Congress for its consideration.

LIST OF DOCUMENTS
COMPREHENSIVE FRAMEWORK STUDIES

MAIN REPORT

Appendix I	History of Study
Appendix II	The Region
Appendix III	Legal and Institutional Environments
Appendix IV	Economic Base and Projections
Appendix V	Water Resources
Appendix VI	Land Resources and Use
Appendix VII	Mineral Resources
Appendix VIII	Watershed Management
Appendix IX	Flood Control
Appendix X	Irrigation and Drainage
Appendix XI	Municipal and Industrial Water
Appendix XII	Recreation
Appendix XIII	Fish and Wildlife
Appendix XIV	Electric Power
Appendix XV	Water Quality, Pollution Control and Health Factors
Appendix XVI	Shoreline Protection and Development (not applicable to Upper Colorado Region)
Appendix XVII	Navigation (not applicable to Upper Colorado Region)
Appendix XVIII	General Program and Alternatives



SUMMARY

This ~~appendix~~ document presents the results of comprehensive investigations for formulation of framework plans to provide a broad guide to the best use, or combination of uses, of water and related land resources to meet foreseeable needs. It provides appraisals of natural resources and their geographic distribution, projections of future requirements, associated problems and needs, and presents a framework program and alternatives to serve as a general guide for resource development and conservation to the year 2020, with intermediate objectives to the years 1980 and 2000.

The Upper Colorado Region comprises the drainage of the Colorado River above Lee Ferry, Arizona, and the Great Divide Basin in south-central Wyoming. The region includes parts of Arizona, Colorado, New Mexico, Utah and Wyoming and totals 113,496 square miles in area. Nearly two-thirds of the land is in public ownership.

The region is sparsely populated, averaging only three persons per square mile. Only Grand Junction, Colorado, and Farmington, New Mexico, exceed 20,000 population. The 1965 population of 366,000 is projected to nearly double by 2020.

The region is and probably will remain largely an exporter of raw and partially processed materials and other resources, including water and an importer of finished products. A majority of the available water is now committed to downstream delivery and transmountain diversion. The minerals industry is engaged in mining, partial refining, and transport of numerous commodities to other areas for finished processing and manufacture.

Agriculture is livestock oriented. Beef cattle and sheep are produced on the range and irrigated-farm base and are then mostly marketed outside the region. About 87 percent of the projected production of electrical energy will be exported. The bulk of mineral production will be for petroleum, uranium, coal, molybdenum and trona production.

Outstanding opportunities are available to local residents to participate in year-round recreation activities. A great number of visitors from adjoining regions and throughout the United States also enjoy the fishing, hunting, skiing, camping, and other outdoor sports.

The Office of Business Economics and Economic Research Service (OBERS) March 1968 projections were modified to better fit the situation in the region.

These modified projections are designated as the regionally interpreted OBERS (RI OBERS) projections and are the basis for the framework

plan. This plan is described in detail and then is followed by alternative plans that reflect emphasis on different uses for the available water supplies and resources. The alternative plans are identified as:

1. States' alternative to the framework plan (6.545 million acre-foot) level of development,

2. States' alternative at the 8.16 million acre-foot level of development, and

3. States' alternative for water supply physically available at site in the region (9.44 million acre-feet).

Comparisons of the framework plan and alternate levels of development are shown in the table on the following page.

The proposed levels of development meet the requirements of OBERS projections and use the available resources of the region in varying degrees. Water in the region, as in all semiarid areas, is the limiting criterion. However, it appears that the commitments of the Colorado River Compact can be met and, except for some water deficiency for fish and wildlife uses in Arizona and New Mexico and local shortages during low streamflows, on-site demands can be met for the 6.5 MAF development level. At higher levels, augmentation will be required.

Costs have been estimated only for the framework plan. Installation and annual operation, maintenance, and replacement (OM&R) costs for water related and associated development for the 1966-80, 1981-2000, and 2001-2020 time frames are shown in the following tabulation:

Development costs for framework plan
($1,000)[1/]

	Water development	Associated development	Total development
Installation			
1966-1980	1,190,300	2,700,840	3,891,140
1981-2000	1,074,350	5,982,310	7,056,660
2001-2020	658,780	1,397,680	2,056,460
Annual OM&R (change by end of period)			
1966-1980	17,540	215,950	233,490
1981-2000	20,290	452,780	473,070
2001-2020	9,440	(-)21,720	(-)12,280

1/ A Federal-non-Federal breakdown is included in the section on costs.

Comparison of framework plan and alternatives for water and selected related requirements, Upper Colorado Region

	Unit	1965 base	Framework plan in 2020	States' alternatives: 6.5 million acre-feet in 2020	States' alternatives: 8.16 million acre-feet in 2020	States' alternatives: Water available at site in 2020
On-site Depletions						
Irrigation	1,000 ac.-ft.	2,128	3,294	3,297	3,658	4,089
Export	1,000 ac.-ft.	551	1,653	1,455	2,203	2,817
Other uses	1,000 ac.-ft.	132	941	1,136	1,642	1,878
Less import	1,000 ac.-ft.	(-)3	(-)3	(-)3	(-)3	(-)3
Subtotal		2,808	5,885	5,885	7,500	8,781
Main-stem reservoir evaporation	1,000 ac.-ft.	643	660	660	660	660
Total		3,451	6,545	6,545	8,160	9,441
Agricultural Activity						
Irrigated land	1,000 acres	1,622	2,122	2,118	2,354	2,579
Dry cropland	1,000 acres	603	503	503	503	503
Range grazing production	1,000 AUM's	6,368	7,665	7,665	7,665	8,392
Timber production	Mil. cu. ft.	48	340	340	340	340
Industrial Activity						
Electric power						
Thermal	Megawatts	1,335	42,081	42,591	47,591	50,391
Hydro	Megawatts	1,300	1,300	1,300	1,300	1,300
Minerals						
Shale oil	Mil. bbl./day	0	0	1.5	4	4
Coal byproducts	Equivalent mil. bbl./day	0	0	0.2	0.8	1.6
Potash	Tons/day	0	0	4,100	4,100	4,100
Fish and Wildlife - Recreation						
Fish and wildlife						
Sport hunting	1,000 man-days	1,268	2,374	2,634	2,955	3,072
Sport fishing	1,000 man-days	3,547	8,667	9,221	9,691	10,094
Recreation	Mil. rec.-days	56	225	225	225	225
Watershed Management and Flood Control						
Watershed management						
Sediment yield reduction	Ac.-ft./yr.		2,764	2,764	2,764	2,764
Flood control						
Flood damage reduction	1,000 dollars		6,744	7,063	7,754	
Economic Activity (Economic Boundaries)						
Population	1,000's	337	660	746	901	
Employment	1,000's	111	251	285	343	
Gross regional product	Mil. dollars	1,142	10,470	11,712	13,906	
Personal income	Mil. dollars	730	7,572	8,570	10,529	

The average annual expenditures for the on-going water development program for the 1965-69 period adjusted to the 1965 price level are $82,120,000, of which about $70,880,000 has been used for the program and $11,250,000 has been used for OM&R. An increase of about $8,670,000 annually will be needed to accomplish the installation of the 1966-80 portion of the water development programs.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

TABLES

TABLES (Continued)

TABLES (Continued)

TABLES (Continued)

FIGURES

MAPS

PART I

INTRODUCTION

This appendix sets forth the national and regional objectives of planning for the Upper Colorado Region, cites the authorities under which planning studies are accomplished, and presents a discussion of the policies, procedures, and constraints which need to be recognized.

The present status of water and related land development is described, needs and demand are enumerated, preservation considerations are outlined, and the water and related land resources that are available to meet the projected needs are discussed. A regional framework plan is developed along with alternatives to reflect gross requirements for facilities and programs for the time periods 1980, 2000, and 2020. Finally, comparisons are made among the framework plan and the alternatives.

National projections for population, employment, gross national product, personal income and per capita income were provided by the Office of Business Economics, Department of Commerce, and the Economic Research Service, of the Department of Agriculture, and are primarily an extension of past trends. For this study, these projections are designated as "OBERS" published in March 1968.

It was necessary to modify crop production needs to be consistent with projected livestock output as well as to adjust other sectors of the economy. These data are identified as regionally interpreted OBERS level of development or "RI OBERS," and are the basis of the framework plan.

Additional alternatives were developed to reflect capability of the region to supply goods and services not fully evaluated in the OBERS projections.

National Objectives of Planning

The basic objective in the formulation of the framework plans for the designated regions of the Nation is to provide the best use, or combination of uses, of water and related land resources to meet foreseeable needs projected to the year 2020. In pursuit of this basic conservation objective, full consideration is given to each of the following objectives and reasoned choices are made between them when they conflict.

a. Development - National economic development and development of each region within the country are essential to the maintenance of

national strength and the achievement of satisfactory levels of living. Water and related land resources development and management are essential to economic development and growth through concurrent provision for--

Facilities to store and distribute an adequate water supply of suitable quality for domestic, municipal, agricultural, and industrial uses.

Hydroelectric power where its provision can contribute advantageously to a needed increase in power supply.

Reduction of flood damage to a reasonable level by use of both structural and nonstructural measures.

Land stabilization measures where feasible to protect land for beneficial purposes.

Accelerated intensive forest management practices to meet rapidly increasing demand for forest products.

Land drainage measures, as required to obtain the best use of land.

Watershed protection and management measures to preserve and enhance resource use opportunities.

Outdoor recreational and fish and wildlife facilities to enhance recreational opportunities.

Any other means by which development of water and related land resources can contribute to economic growth and development.

b. Preservation - Proper stewardship in the long-term interest of the Nation's natural bounty requires in particular instances that--

There be protection and rehabilitation of resources to insure availability for their best use when needed.

Open space, green space, and wild areas of rivers, lakes, beaches, mountains, and related land areas be maintained and used for recreational purposes, and

Areas of significant natural beauty, historical, archeological, cultural, and scientific interest, be preserved and managed primarily for the inspiration, enjoyment, and education of the people.

Regard for the unique character of the region, which should remain insofar as possible a spacious, uncrowded land for the enjoyment of all the people of the United States.

c. Well-being of People - Well-being of all[1] of the people shall be the overriding determinant in considering the best use of water and related land resources. Hardship and basic needs of particular groups within the general public shall be of concern, but care shall be taken to avoid resource use and development for the benefit of a few. In particular, policy requirements and guides established by the Congress and aimed at assuring that the use of natural resources, including water and air resources, and the preservation and use of historical and archeological resources shall be observed in order to safeguard the interests of all of our people.

Regional Objectives and Goals

The basic objective and goal in formulating the framework plan for the Upper Colorado Region is to provide a broad guide to determine how the water and related land resources requirements for the foreseeable short- and long-term needs might be met. The development of agricultural resources, the expansion of the industrial base to process and utilize the vast deposits of minerals and fuels is considered. In addition, many opportunities exist to provide facilities that would attract visitors from outside of the region to enjoy many types of year-round outdoor recreation, including the excellent fishing and hunting. Thus, this area of great open spaces could provide some of the essence of a quality environment for residents and other citizens of the Nation.

Specific objectives include:

a. Provide facilities for storage and distribution of the water supply available from the Colorado River system.

b. Provide structural and nonstructural flood damage prevention measures to reduce damages from floods.

c. Manage watersheds to preserve and enhance the land and water for multiple uses and reduce soil erosion and sedimentation.

d. Increase livestock and crop production from irrigated and range lands.

e. Encourage exploration, mining, and processing of the minerals and fuels available.

---

[1] The existing Colorado River Compact imposes obligations on the region and specifically reserves water for use of the States of the region in relation to other areas of the Colorado River drainage.

f. Develop the timber resources to realize the appropriate sustained yield.

g. Protect and enhance the natural environment and the significant historical, archeological, and cultural resources, and salvage scientific data that will otherwise be damaged or destroyed by development activities.

Authorization

The Upper Colorado Region is one of the river basins in the United States included in a nationwide program of comprehensive river basin planning for the development, use, and management of the water and related land resources. This program stems from recommendations of the Senate Select Committee on National Water Resources, which were presented by the President in the Fiscal Year 1963 budget.

The Water Resources Planning Act (P.L. 89-80, July 22, 1965) established the Water Resources Council. The President transferred the functions and committee organization of the Interagency Committee on Water Resources to the Water Resources Council on April 10, 1966. This transfer included the Pacific Southwest Interagency Committee (PSIAC). By letter of October 10, 1966, the Water Resources Council requested the PSIAC to take leadership and coordinate the comprehensive studies in the Pacific Southwest, including the Upper Colorado Region. PSIAC accepted this responsibility by letter of November 21, 1966. Funds were provided and an organization meeting to begin the Upper Colorado Region study was held on January 31, 1967. The Upper Colorado River Commission was subsequently designated as the chair agency.

The States of Arizona, Colorado, New Mexico, Utah, and Wyoming and the Upper Colorado River Commission participated with the following Federal agencies in this investigation:

a. Department of Agriculture - Soil Conservation Service, Economic Research Service, and Forest Service.

b. Department of the Army - Corps of Engineers.

c. Department of Commerce - National Weather Service; Economic Development Administration.

d. Department of Health, Education, and Welfare - Public Health Service.

e. Department of the Interior - Bureau of Indian Affairs, Bureau of Land Management, Bureau of Mines, Bureau of Outdoor Recreation, Bureau of Reclamation, Bureau of Sport Fisheries and Wildlife, Geological Survey, National Park Service.

f. Department of Transportation - Federal Highway Administration.

g. Environmental Protection Agency - Water Quality Office.

h. Federal Power Commission.

Planning Policies, Procedures, and Constraints

Comprehensive framework planning for the Upper Colorado Region required a coordinated analysis for all water and related land use with consideration of the constraints and controls imposed by the physiography of the region, the overall short water supply, and the legal and institutional environments and preservation of environmental values. The Upper Colorado Region study concerns the upper half of the Colorado River Basin and the Great Divide Basin. The division of the Colorado River Basin was defined by an interstate compact specifying upper and lower basin water use allotments, priorities in types of uses, and downstream delivery requirements. Furthermore, an International Water Treaty sets forth obligations of the upper and lower basins under certain conditions to provide water for Mexico; under other circumstances this obligation will be assumed by the United States as specified by P.L. 90-537. Each of the seven Colorado River Basin States has separate water codes and, in addition, the five Upper Basin States have agreed to their relative uses of Colorado River water through an interstate compact. Thus, as would be expected, there are certain necessary departures from the aforementioned uniform national objectives, standards, and procedures due to the existing constraints imposed by these State and Federal agreements.

The largest present use of water is for irrigation. This use ranges from the small diversions by the individual landowner to the major storage and diversion works of the Federal projects. Irrigated crops contribute substantially to the economy and the development of new irrigation projects has a significant impact on local areas and the region. Therefore, the large irrigable areas considered in alternative plans must be analyzed on an area or regional basis.

The base year, 1965, was adopted for purpose of the plan formulation. All projects either developed during the period 1965-70 or funded by July 1968 are considered available to meet 1980's demands. The year 1970 was not treated as a "projection" year in the same sense that 1980, 2000, and 2020 were considered throughout the study. Data for the study are generally presented by regional, subregional, and state breakdowns.

The procedure in formulating the comprehensive plan was first to prepare the following appendices:

Appendix III - Legal and Institutional Environments
Appendix IV - Economic Base and Projections

Appendix V - Water Resources
Appendix VI - Land Resources and Use
Appendix VII - Mineral Resources
Appendix VIII - Watershed Management
Appendix IX - Flood Control
Appendix X - Irrigation and Drainage
Appendix XI - Municipal and Industrial Water
Appendix XII - Recreation
Appendix XIII - Fish and Wildlife
Appendix XIV - Electric Power
Appendix XV - Water Quality, Pollution Control, and Health Factors

Plans and programs from the foregoing appendices constituted the basis of this appendix. One region in the Pacific Southwest considered two additional appendices - XVI, Shore Line Projection and Development, and XVII, Navigation. These are not presently applicable to the Upper Colorado Region. Recreational navigation was considered in the recreation appendix where appropriate.

A regional determination of water requirements for all uses was made. In selecting a general plan of water and land development, only general consideration was given to cost-repayment capacity relationships inasmuch as practically all such development is covered by existing authorization. The remaining portion of the plan is based essentially upon reasoned approximations and the judgment of experienced planners.

Policy and constraints statements adopted by PSIAC and used in this study follow.

Water export/import constraints

All existing and authorized diversions to and from the region are recognized and the expected transfers of water included as a loss to the transferring-out region and available for use in the transferring-in region.

The distribution of water between regions is made in accordance with existing Federally approved compacts or legal agreements. In some cases, decisions had to be made as to the future division of water between regions within a state.

Allocation of water among competing areas and uses

Assumptions concerning allocation of water among competing areas and uses are of paramount concern. Historically, in the West, water has been appropriated for use under state law. It is expected that future uses will be sanctioned under similar jurisdictional arrangements. Established water rights have inherent economic value and are normally associated with beneficial use of specific land or property. Western history and western

water law record the extreme sensitivity of questions associated with allocation of water resources among competing areas and uses.

Experience has shown that expanding urban areas almost always have adequate capacity to pay whatever reasonable cost is involved in obtaining a supplemental water supply.

In recognition of the foregoing, it is concluded that the basic assumptions necessary to follow in Type I planning are along the following lines:

1. Water presently being beneficially used will not be diverted to supplement growing urban or industrial demands, except where urban or industrial growth occupies land on which water is beneficially used for another purpose.

2. Allocation of newly developed water supplies will be predicated on the projected demands for commodities, services, and other purposes.

3. Available water allocated under compacts, agreements, or laws but not presently in beneficial use by the allottee will be available for future beneficial use of the allottee (state or other organizational unit). This study will rely on appropriate state laws or policies for determination of priorities of use among competing areas and uses.

4. The ocean should be considered available and plans for its use as a water resource could be included.

Water quality criteria

Consideration of water quality will provide sufficient latitude to permit future growth and full development of water use, provided the condition of the water does not reflect failure to apply all corrective measures which are physically possible and economically feasible. These water quality considerations shall not inhibit application in any way of existing interstate compacts or court decrees or intrastate appropriation of water.

Wild and scenic rivers

The relationships of Wild and Scenic Rivers to land use, watershed management, water development, and other functions will be considered.

Environmental quality

Maintenance of environmental quality deserves high priority in planning for the future. There is perhaps no other area in the 48 coterminous states which remains as uncontaminated as this region, and every consideration should be given to the type and manner of development which will

keep it this way. Water pollution control can be accomplished within reasonable limits, air pollution is a problem in only a few limited localities, and the human population is widely dispersed. Erosion is a continuing problem that requires appropriate watershed management and treatment. This study gives cognizance to these assets for a pattern of future development which will preserve or enhance the esthetic and health-related attributes. Development that deteriorates environmental qualities will be carefully evaluated.

PART II

PRESENT STATUS OF WATER AND RELATED LAND DEVELOPMENT

This section summarizes the 1965 level of water and land utilization, management, and development. A brief description is presented of the 1965 uses of water by principal categories of use and by subregion and states. The present status of the 72.2 million acres of land area is summarized by use, ownership, soil types, and vegetal cover types. An additional 0.4 million acres are covered by water. Appropriate tables offer ready reference to quantitative figures.

Summary of 1965 Water Uses

The total virgin or undepleted supply of water is estimated to be 14.9 million acre-feet annually. This estimate is based upon the computed outflow from the region as measured at Lee Ferry, Arizona, 1 mile below the confluence of the Paria and Colorado Rivers for the 52-year period, 1914-65.

On-site depletions for 1965 related to man's activities in the region were 3.45 million acre-feet. These depletions include the average annual uses at the 1965 level of development and the long-term average or normalized evaporation from main-stem reservoirs. Data have been adjusted where necessary to reflect average conditions that may not have occurred in some areas during the year 1965.

Estimates of on-site depletions were made specifically for this framework study and are not to be construed as depletions charged to the various states under the provisions of the Colorado River and Upper Colorado River Basin Compacts. In particular, they are site-located and do not necessarily reflect direct relationships to streamflow diminishment at Lee Ferry. In a reconnaissance study of this type, the on-site depletions have been applied directly in estimating both virgin and present modified flows. Historic water shortages to the on-site depletions have been recorded.

By far the largest consumptive use was by the 1.6 million acres of irrigated crops, associated seeped and incidental phreatophyte areas, and irrigation reservoir evaporation. These uses account for 62 percent of the total. Minor water uses for other purposes were municipal and industrial (0.8 percent), minerals and power (1.6 percent), stock-pond evaporation and livestock use facilities (1 percent), and recreation and augmented fish and wildlife (0.4 percent). Over one-half million acre-feet of water was being exported from the region by Colorado and Utah. Evaporation losses from main-stem regulating reservoirs, Flaming Gorge and Lake Powell, for 1965 normalized conditions were 643,000 acre-feet.

PART II

PRESENT STATUS OF WATER AND RELATED LAND DEVELOPMENT

For flexibility in analysis and planning, the region has been divided into three subregions designated as Green River, Upper Main Stem, and San Juan-Colorado. The Great Divide Basin of southwestern Wyoming, not normally considered a part of the Upper Colorado drainage, is included in the Green River Subregion but does not contribute to or deplete Colorado River waters. Summaries of stream depletions computed by types of use for each state and subregion are shown in Tables 1 and 2.

Explanatory notes on some water uses shown in Tables 1 and 2 and description of the present status of related items of water quality, health factors, and flood control follow.

Municipal and industrial

Tabulated uses include basic municipal, rural household, industry, and evaporation of 2,300 acre-feet from 30 municipal reservoirs.

Thermal-electric power

Water was consumed principally for condenser cooling purposes at 10 plants with a total generating capacity of 1.4 million kilowatts.

Fish and wildlife

About 6,700 acre-feet was consumed by 111 fish facilities and 5,000 acre-feet for 104 wildlife facilities. Evaporation from water areas was computed only on those installations constructed and utilized primarily for fish and wildlife.

Recreation

The computed total was based upon a rate of 7.7 gallons per recreation day for 56 million recreation days of use. No reservoir has recreation as a dominant purpose except fish and wildlife facilities discussed previously.

Stock-pond evaporation and livestock use

Average annual evaporation from 22,035 man-made stock ponds with water surface area of 14,600 acres used primarily for livestock water was 23,900 acre-feet. Livestock use by approximately 1 million animals (in cattle units) was 11,000 acre-feet.

Irrigation

Consumptive use on 1,621,500 acres of irrigated cropland was 1,697,300 acre-feet for 1965 average conditions and cropping pattern. Consumptive use rates were computed on 61 evaluation areas utilizing the Blaney-Criddle

PART II

PRESENT STATUS OF WATER AND RELATED LAND DEVELOPMENT

Table 1 - Water uses by states, 1965, Upper Colorado Region

Type of use	On-site depletions in acre-feet					
	Arizona	Colorado	New Mexico	Utah	Wyoming	Total
Municipal and industrial	1,500	15,900	2,400	5,000	2,600	27,400
Electric power (thermal)		3,200	15,300	1,300	3,400	23,200
Minerals	-	16,900	1,600	9,400	5,800	33,700
Fish and wildlife	600	2,700	400	7,900	100	11,700
Recreation	-	700	100	300	200	1,300
Stock-pond evaporation and livestock use	1,100	20,700	2,400	6,200	4,500	34,900
Subtotal	3,200	60,100	22,200	30,100	16,600	132,200
Irrigation						
Consumptive use	4,400	991,300	76,000	404,400	221,200	1,697,300
Incidental use	500	198,700	15,000	81,000	20,400	315,600
Reservoir evaporation	2,000	27,100	31,700	30,200	23,900	114,900
Total irrigation	6,900	1,217,100	122,700	515,600	265,500	2,127,800
Export						
Diversions		417,100		109,500		526,600
Reservoir evaporation		12,300		11,400		23,700
Less water import				(2,600)		(2,600)
Subtotal of all above	10,100	1,706,600	144,900	664,000	282,100	2,807,700
Main-stem reservoir evaporation						643,000
Region total						3,450,700

Table 2 - Water uses by subregions, 1965, Upper Colorado Region

Type of use	On-site depletions in acre-feet			
	Green River	Upper Main Stem	San Juan-Colorado	Region total
Municipal and industrial	7,900	12,300	7,200	27,400
Electric power (thermal)	6,300	1,600	15,300	23,200
Minerals	17,200	11,900	4,600	33,700
Fish and wildlife	8,000	1,300	2,400	11,700
Recreation	500	500	300	1,300
Stock-pond evaporation and livestock use	13,300	11,200	10,400	34,900
Subtotal	53,200	38,800	40,200	132,200
Irrigation				
Consumptive use	662,400	747,400	287,500	1,697,300
Incidental use	113,600	167,300	34,700	315,600
Reservoir evaporation	42,400	16,900	55,600	114,900
Total irrigation	818,400	931,600	377,800	2,127,800
Export				
Diversions	109,500	414,600	2,500	526,600
Reservoir evaporation	11,400	12,300		23,700
Less water import			(2,600)	(2,600)
Subtotal of all above	992,500	1,397,300	417,900	2,807,700
Main-stem reservoir evaporation	67,000		576,000	643,000
Region total	1,059,500	1,397,300	993,900	3,450,700

method and latest available data on local seasonal crop coefficients. Adjustments were made to reflect present average short water supply on 549,300 acres. Also there were 124,400 acres idle or land not irrigated in the average year.

Incidental use on water-consuming, noncropped areas was estimated on those areas which consumed water incidental to the cropped lands as a result of the practice of irrigation. Incidental use represents 18.6 percent of the consumptive use by irrigated crops.

Reservoir evaporation

Evaporation from 315 reservoirs (other than main stem) was computed for 1965 normal operation and total 138,600 acre-feet. Estimated evaporation from regulating and exchange reservoirs used in connection with export was 23,700 acre-feet of the above total.

Evaporation loss from main-stem regulating reservoirs (Flaming Gorge, 67,000 acre-feet, and Lake Powell, 576,000 acre-feet) for 1965 normalized conditions was 643,000 acre-feet. It should be noted, however, that these evaporation losses will be charged against the separate states only if curtailment of use is required in the Upper Colorado River Basin to make delivery required by the compact at Lee Ferry. The percentages of evaporation to each state would then be as follows: Colorado, 51.75; New Mexico, 11.25; Utah, 23.0; and Wyoming, 14.0.

Water exports

Transmountain diversion records for 39 of the currently operative facilities were analyzed to reflect 1965 average export of water from the region. Normalized 1965 discharge by 22 diversions in Colorado was 417,100 acre-feet and by 17 diversions in Utah was 109,500 acre-feet.

Diversions in Utah of 109,500 acre-feet were to the Great Basin Region. Colorado diversions were: 353,400 acre-feet to the Platte River (Missouri Basin Region), 60,600 acre-feet to the Arkansas River (Arkansas-White-Red Region), and 3,100 acre-feet to the Rio Grande Region.

Water imports

Inflow to the region through a transmountain diversion from Sevier River in the Great Basin Region to the Paria River averages 2,600 acre-feet. This represents a credit against local use within this region.

Water quality

The quality of the surface and ground waters is generally good in all three subregions. Very good quality is to be found at the head of

streams near the mountain divides. Degradation of chemical, physical, and biological quality is evident as streams progress downward, resulting from hydrologic, geologic and man-made influences. Pollution problems of virtually every form, although generally limited in magnitude, may be found in the region.

Salinity is a major water-quality problem particularly in the lower part of the Colorado River Basin. The principal effect of salinity increases on uses in the Upper Colorado Region will be confined to limited areas generally in the lower reaches of the stream systems. Salt-loading and salt-concentrating effects of consumptive use or depletion are the primary causes of salinity increases. Of the present total salt burden at Lees Ferry, it is estimated that 50-60 percent of the salts are derived from geologic diffused sources, 25-40 percent from irrigation return flows, 9 percent from mineral springs and other geologic point sources, and 1 percent from municipal and industrial waste water effluents.

The Colorado River from below Grand Junction, Colorado, downstream to Lee Ferry has an average TDS concentration varying between about 500 mg./l. and 700 mg./l. The Green River, except for the Flaming Gorge Reservoir area, and the San Juan River do not exceed 500 mg./l. of dissolved solids as measured on a long-term average. The concentrations of dissolved salts in some tributary streams are considerably higher.

Drainage from abandoned and active mines is a problem in portions of the Upper Main Stem and San Juan-Colorado Subregions. This drainage eliminates about 120 miles of stream fishery. Stream pollution from discharges of radioactive mill wastes, formerly severe, has in most cases been reduced to acceptable levels.

Suspended sediment concentrations and loads vary widely. Sediment in some stream reaches has historically been detrimental to consumptive uses of water as well as to fisheries and recreation.

Inadequately treated effluents from waste water treatment works have caused depressed oxygen levels, potentially hazardous coliform bacteria densities, overproduction of algae, and other deleterious effects in many short reaches of streams.

Health factors

Various environmental health problems exist. Epidemiological data suggest that for potentially waterborne diseases the incidence rate is 2.5 times that for the rest of the country.

Watersheds primarily intended for public water supplies are being used more and more by man for other purposes, thereby making them even more susceptible to pollution and contamination. Water supplies vary

considerably in bacteriological and chemical quality. Based on available data, it is estimated that 20 percent of the population drinks water that does not receive adequate treatment.

Improper disposal of solid wastes can result in hazardous environmental health conditions. A recent survey found that of the disposal sites presently in operation 30 percent had surface drainage problems, 13 percent had leaching problems, and 12 percent were placing wastes in the water table. Only 4 percent could be considered as adequate sanitary landfill operations.

Radiological problems could pose a health threat unless measures are taken to safeguard against them. Potential radiological hazards associated with uranium tailing piles are presently under study. Airborne transport of particulate radioactive matter and construction of buildings on tailing piles which emit radon gas are recent problems which have become of concern.

Air pollution problems are scattered. There are a number of industrial plants in rural areas that have associated air pollution problems such as the cement, sugar, alfalfa mills, and the wood product plants, with their burners and open burning of wastes.

Flood control

There were few flood control measures in 1965. There were no permanent-type levee and channel projects. Temporary channel improvements had been accomplished at several locations, through the use of Federal emergency funds, in anticipation of flood flows and to restore channels destroyed by floods. Storage for flood control consisted of 2,100 acre-feet in three headwater detention reservoirs and 1,218,000 acre-feet operated on a flood forecast basis in four water conservation storage reservoirs. Land treatment measures had been installed on 9,292,000 acres of watershed area for multiple purposes, including flood prevention and sediment control. A summary of the 1965 programs in operation for flood control is given in the tabulation on the following page.

There were 105 reservoirs, each with a storage capacity of 1,000 acre-feet or more, having a combined storage capacity of nearly 8 million acre-feet (excluding Lake Powell). Beneficial effects on the region's flood problems have been substantial although flood control operation is incidental to other uses.

Subregion and State	Maximum flood control storage in 1,000 acre-feet: Single-purpose reservoir	Maximum flood control storage in 1,000 acre-feet: Multiple-purpose reservoir	Watershed treatment areas in 1,000 acres
Green River			
Colorado	0	0	1,967
Wyoming	0	0	1,227
Utah	0	0	2,508
Subregion total	0	0	5,702
Upper Main Stem			
Colorado	2.0	17	1,638
Utah	0	0	179
Subregion total	2.0	17	1,817
San Juan-Colorado			
Colorado	0.1	165	693
Utah	0	0	368
New Mexico	0	1,036	611
Arizona	0	0	101
Subregion total	0.1	1,201	1,773
Region total	2.1	1,218	9,292

Summary of 1965 Land Uses

Almost every acre of land in the region is presently used for some activity. On most areas there are several concurrent uses. The multiple land use for 1965 was as shown in the following tabulation.

1965 Land Use--1,000 Acres

Cropland and pasture		Wilderness, natural, historic, and cultural	2,636
Irrigated	1,622		
Dry	603		
Livestock grazing	60,442	Developed mineral production	37
Timber production[1/]	9,419	Developed fish and wildlife	299
Urban and industrial	331	Military	114
Transportation and utilities	598	Classified watersheds	258
Developed recreation	71	Water area < 40 acres	405

1/ Economic Subregions--other figures Hydrologic Subregions.

Other extensive uses include general wildlife habitat, nonspecific recreation, such as driving and viewing for pleasure, greenbelt areas, and others. The region thus had almost every acre contributing to the welfare and economy of man. New uses can be added to or substituted for present uses.

A brief description of the principal uses supplemented by appropriate tables follows.

Irrigated cropland

There were 1,621,500 acres of land irrigated, mainly used to produce feed to support the livestock industry. The feed produced was hay, both grass and legume mixtures, alfalfa, small grain, and irrigated pasture. In certain locations cash crops such as sugar beets, malting barley, feed barley, grain corn, dry beans, vegetables, and fruits were produced. Some of the grains were sold or used as feed, in keeping with the individual land operator's needs and desires. There were about 124,400 acres idle and not irrigated in the average year for a variety of reasons.

Table 3 indicates the distribution of the principal irrigated crops by subregion. Total lands under irrigation, including idle for the five states of the region, are as follows:

	1,000 acres
Arizona	10.9
Colorado	914.0
New Mexico	52.9
Utah	332.6
Wyoming	311.1
Total	1,621.5

Dry cropland

There were 603,400 acres of dry cropland in the region. The major crops were hay, pasture, and wheat. The other most prominent crop is pinto beans, grown mainly in the San Juan-Colorado Subregion. Acreages of specific crops by subregions are shown in Table 4.

Livestock grazing

About 60,442,000 acres of land were grazed in 1965, although only 54,624,000 acres of this total were considered suitable for this use. The difference represents the land not considered suitable for grazing under proper management. Data concerning rangeland livestock grazing are summarized on page 19.

Table 3 - Crop distribution on irrigated acreage, 1965, Upper Colorado Region

Crop	Hydrologic subregions: Green River (acres)	Upper Main Stem (acres)	San Juan-Colorado (acres)	Region (acres)
Hay				
Alfalfa	109,200	127,400	61,700	298,300
Other hay				
Improved	50,000	40,000	12,000	102,000
Native	163,300	83,800	11,400	258,500
Subtotal	322,500	251,200	85,100	658,800
Pasture				
Rotation (cropland)	116,300	88,900	42,100	247,300
Permanent (noncropland)	116,200	89,000	42,000	247,200
Other (noncropland)	63,100	55,000	45,700	163,800
Subtotal	295,600	232,900	129,800	658,300
Corn silage	7,700	18,300	11,700	37,700
Feed grains				
Oats	9,200	13,200	4,800	27,200
Barley (exclude Moravian)	14,800	3,700	5,900	24,400
Corn	600	13,400	2,200	16,200
Subtotal	24,600	30,300	12,900	67,800
Other grains				
Barley (Moravian)	0	15,000	0	15,000
Wheat	7,200	900	7,400	15,500
Subtotal	7,200	15,900	7,400	30,500
Other crops				
Orchard	500	14,700	3,100	18,300
Sugar beets	1,700	9,800	0	11,500
Dry beans	0	8,100	500	8,600
Truck crops	300	1,800	1,800	3,900
Potatoes	100	900	700	1,700
Subtotal	2,600	35,300	6,100	44,000
Idle land	52,100	34,500	37,800	124,400
Total irrigated acres	712,300	618,400	290,800	1,621,500

Table 4 - Crop distribution on dry cropland,
1965, Upper Colorado Region

Crop	Hydrologic subregions			
	Green River	Upper Main Stem	San Juan-Colorado	Region
	(acres)	(acres)	(acres)	(acres)
Forage				
Hay	31,500	10,000	12,200	53,700
Cropland pasture	26,500	5,400	27,200	59,100
Subtotal	58,000	15,400	39,400	112,800
Feed grains				
Oats	9,400	2,100	900	12,400
Barley (feed)	12,400	1,600	1,700	15,700
Subtotal	21,800	3,700	2,600	28,100
Other grains				
Wheat	56,600	8,200	89,800	154,600
Other crops				
Dry beans		3,300	118,700	122,000
Miscellaneous	400	400	400	1,200
Subtotal	400	3,700	119,100	123,200
Idle land				
Fallow	45,000	7,900	62,900	115,800
Temporarily idle	600	1,000	10,800	12,400
Conservation use only	8,600	3,300	33,700	45,600
Subtotal	54,200	12,200	107,400	173,800
Tillage rotation total	191,000	43,200	358,300	592,500
Formerly cropped		2,000	8,900	10,900
Total tillage potential	191,000	45,200	367,200	603,400

Grazing statistics, Upper Colorado Region, 1965
(Rounded to nearest thousand)

	Hydrologic subregions			Region totals
	Green River	Upper Main Stem	San Juan-Colorado	
Grass area used for grazing (acres)	27,219,000	11,809,000	21,414,000	60,442,000
Suitable area used for grazing (acres)	25,971,000	10,361,000	18,292,000	54,624,000
Forage available under proper use[1] (AUM's)	2,962,000	1,456,000	1,520,000	5,938,000
Forage used (AUM's)	3,132,000	1,642,000	1,594,000	6,368,000
Overuse[2] (AUM's)	170,000	186,000	74,000	430,000

1/ Proper use. The degree and time of use of current year's growth which, if continued, will either maintain or improve the range condition consistent with conservation of other natural resources.

2/ Overuse. Utilizing an excessive amount of the current year's growth which, if continued, will result in range deterioration or overgrazing.

Timber production

There were 9,419,000 acres of commercial timberland out of a total area of 27,400,000 acres of forest land in 1965. These commercial lands contained 56.8 billion board feet of saw timber, with the subregional breakdown being Green River--16.3, Upper Main Stem--25.8, and the San Juan-Colorado--14.7. Timber products harvested from commercial forest land in 1965 amounted to 53 million cubic feet, of which half is saw timber (311 million board feet). About 98 percent of the timber is softwood. The timber products harvested percentages by subregion follow.

Subregion	1965 timber product percentages				
	Sawlogs	Veneer	Plywood	Other	All
Green River	90			10	100
Upper Main Stem	68	17	3	12	100
San Juan-Colorado	84	11		5	100
Region	79	11	1	9	100

Urban and industrial

About 331,000 acres of land were used for urban and industrial development with the greatest concentration around the larger centers of

population such as Grand Junction, Colorado, and Farmington, New Mexico. This acreage was divided into 120,000 acres in the Green River Subregion, 146,000 acres in the Upper Main Stem Subregion, and 65,000 acres in the San Juan-Colorado Subregion.

Transportation and utilities

Approximately 598,000 acres of land were used for transportation and utilities. These were divided as follows: 267,000 acres in the Green River Subregion, 227,000 acres in the Upper Main Stem Subregion, and 104,000 acres in the San Juan-Colorado Subregion.

Recreation

Practically all of the public land and most of the private lands were used for some kinds of recreation. These lands were divided between developed and undeveloped acres. Developed acres include campgrounds, picnic areas, shelter areas, overlooks, lakeshores, and others. Undeveloped lands include extensive use areas. The totals include 71,000 acres of developed land, 339,000 acres of water and marsh, and 48,547,000 acres of undeveloped land. Subregion distribution for developed land is Green River--18,000, Upper Main Stem--31,000, and San Juan-Colorado--22,000 acres. A further breakdown of developed and undeveloped land and water is indicated below:

		1,000 acres		
	Recreation Classes	Land	Water and marsh	Total
I	High-density recreation areas	1	-	1
II	General recreation areas	189	95	284
III	Natural environment areas	45,792	239	46,031
IV	Outstanding natural areas	993	5	998
V	Primitive areas (wilderness)	1,414	-	1,414
VI	Historical and Cultural sites	229	-	229
	Regional totals (all classes)	48,618	339	48,957

Wilderness, natural, historic, and cultural

Five wilderness areas and six primitive areas, with a total of about 1,298,000 acres of national forest lands, were included in the wilderness system created in 1964. Some 29,000 acres of Indian lands are set aside as wilderness areas by resolutions of Indian Tribal governing bodies and BLM-administered public lands, totaling 87,000 acres, are classified as wilderness areas. These 1,414,000 acres are important for many compatible uses; e.g., fish and wildlife, watershed management, recreation, and grazing. Outstanding natural areas and historical and cultural sites, totaling 1,227,000 acres of land and water, will have some restrictions on use. Recreation classes IV, V, and VI total 2,641,000 acres, including land and water.

PART II

PRESENT STATUS OF WATER AND RELATED LAND DEVELOPMENT

Minerals

Developed mineral lands, totaling 37,000 acres, are those used for strip mining, shaft mining, oil wells, gas installations, mill buildings, and others. These areas were distributed by subregions as follows: Green River--9,000, Upper Main Stem--11,000, and San Juan-Colorado--17,000. Nearly all lands are open to exploration.

Fish and wildlife

The acreage in use by fish and wildlife is generally accepted as almost the total in the region. There were 299,000 acres of developed fish and wildlife lands. A large part of this acreage is in big game management areas which generally comprise range and forest land resource types and are subject to multiple uses, particularly grazing. In addition, over 400,000 acres of water provided fish and wildlife habitat of which about 350,000 acres were available for public hunting, fishing, or the nonconsumptive appreciation of these natural resources. About 41.2 million acres are classified as key habitat for game and other wildlife; i.e., habitat which must be preserved in quality condition to maintain wildlife populations.

Military

These were lands used for military camps, firing ranges, mineral reserves, and other installations, totaling 114,000 acres. Military use permits for special exercises may occur on additional lands.

Classified watersheds

Watershed area classified was 258,000 acres used for special watershed purposes. These are city or urban water supply areas specifically managed for protection and improvement of water quality.

Water areas

There were 405,000 acres of land covered by water in lakes and reservoirs, each greater than 40 surface acres. This compilation represents full pool level on the reservoirs.

Summary of 1965 Land Ownership and Administration

Nearly two-thirds of the land area was in public ownership under Federal and State administration. The remainder was privately owned, with slightly more than half of this in ownerships by individuals, corporations, or local governments and the remainder in Indian Tribal or individual ownerships held in trust by the Bureau of Indian Affairs. The

approximate distribution of land ownerships is summarized on the map and figure following page 22 and in Tables 5 and 6.

Summary of Lands by Soil Class

Striking differences in land forms, relief, parent material, and climate within short distances have produced intricate soil patterns. Soil patterns have determined present agricultural development and will influence the ultimate potential to be reached.

Mountainous parts of the region are dominated by soils on steep slopes that have gravel, cobble, or stone scattered through their profiles. Moderately deep and shallow soils formed over igneous, metamorphic, and sedimentary rocks are typical. Deep soils within the mountains are mainly restricted to small parks, colluvial slopes, and narrow alluvial valleys.

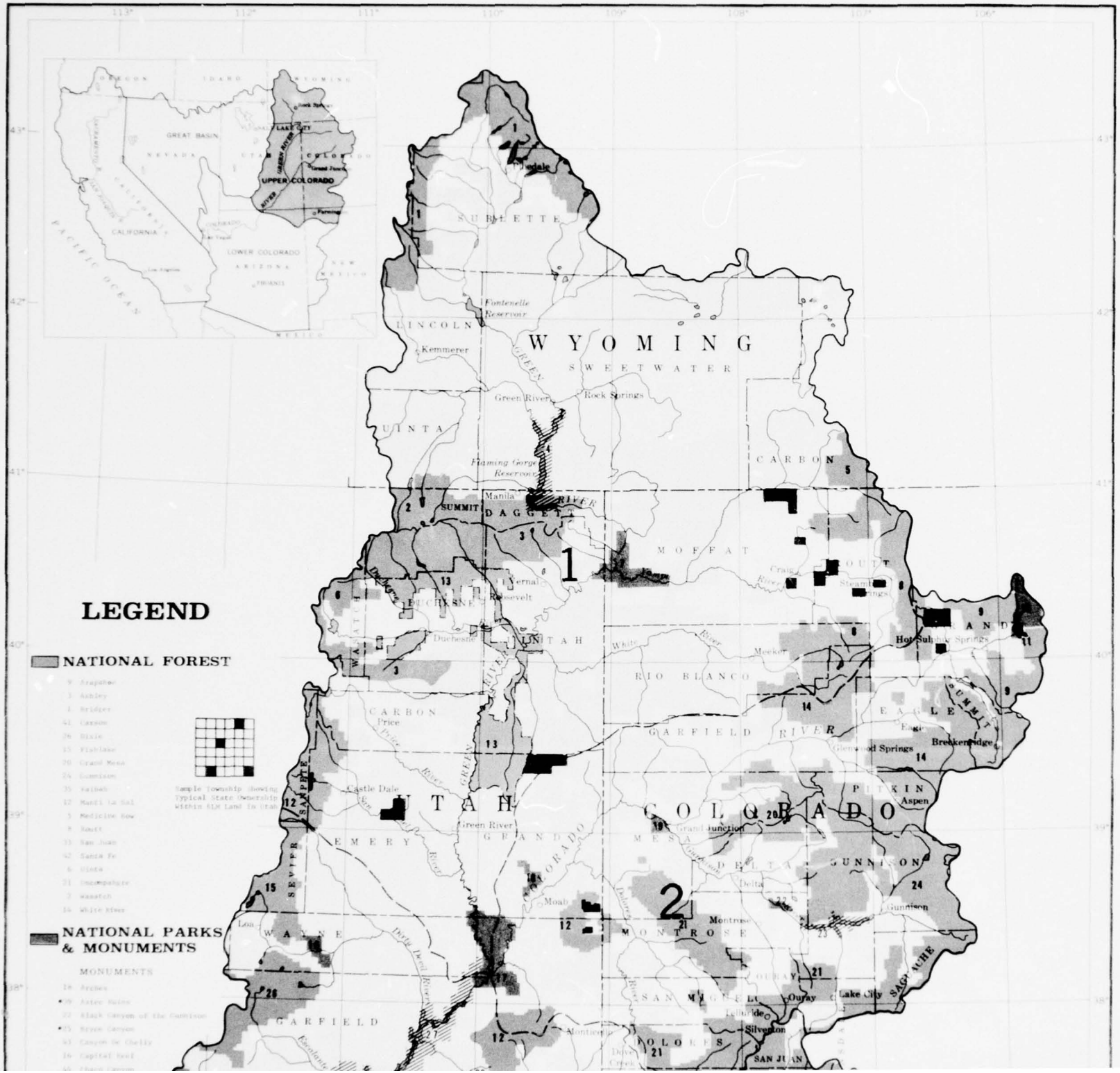
Foothills bordering the lower mountain slopes and canyons dissecting the plateaus are characterized by high proportions of shallow soils and rock outcrop. Short, steep, and irregular slopes are characteristic of the landscapes. Most of the shallow soils are over sandstone or shale and there are prominent exposures of bedrock. Deeper soils are confined to scattered alluvial fans and benches along the drainageways.

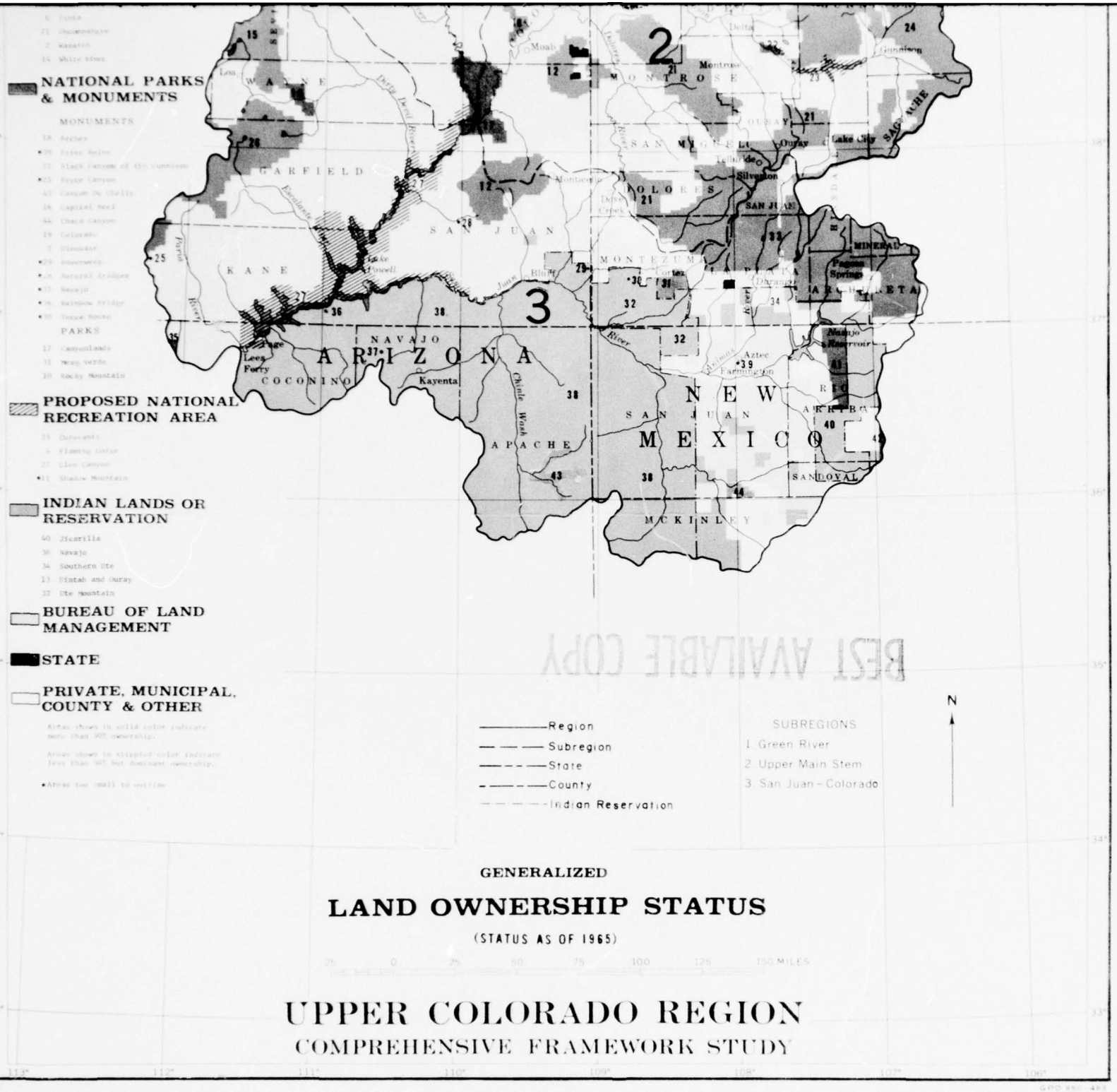
In the valleys and on the broad mesas there are long, smooth slopes. They are occupied by deep and moderately deep soils that have formed in alluvial deposits, residual materials, and wind deposits. These deeper soils are dominantly loamy or clayey and have the physical characteristics needed for successful agricultural production.

Approximately 17,515,000 acres within the region have soils suitable for irrigated agriculture, including 1,621,500 acres that are presently irrigated. Within this vast acreage, however, many soil areas are excluded from consideration for irrigation because of constraints imposed by size and location.

It is estimated that there are 10,823,000 acres of soils within the region that have physical characteristics suitable for dryfarming. This acreage of suitable soils must be further reduced though because some areas are presently irrigated and others have precipitation that is too low for profitable crop production.

Table 7 shows the distribution of irrigation soil classes by states and subregions. The general soil map following page 26 delineates broad map units within the region.


LEGEND
NATIONAL FOREST
NATIONAL PARKS & MONUMENTS
MONUMENTS
Sample Township showing Typical State Ownership within BLM Land in Utah
1
2
WYOMING
COLORADO
UTAH
SUBLETTE
LINCOLN
SWEETWATER
UINTA
CARBON
SUMMIT
DAGGETT
MOFFAT
ROUTT
DUCHESNE
UINTAH
RIO BLANCO
GARFIELD
EAGLE
PITKIN
CARBON
EMERY
GRAND
MESA
DELTA
GUNNISON
MONTROSE
WAYNE
SAN MIGUEL
OURAY
SAGUACHE
GARFIELD
SAN JUAN
Fontenelle Reservoir
Flaming Gorge Reservoir
Kemmerer
Green River
Rock Springs
Manila
Vernal
Roosevelt
Craig
Steamboat Springs
Hot Sulphur Springs
Meeker
White River
Duchesne
Price
Castle Dale
Green River
Grand Junction
Glenwood Springs
Breckenridge
Aspen
Delta
Gunnison
Montrose
Moab
Ouray
Lake City
Telluride
Silverton
Monticello
Dolores
Escalante
Loa
Lake City
GREAT BASIN
UPPER COLORADO
LOWER COLORADO
CALIFORNIA
NEVADA
ARIZONA
COLORADO
NEW MEXICO
PACIFIC OCEAN
GREEN RIVER
SEVIER
SAN RAFAEL
DUCHESNE
WHITE
COLORADO
GUNNISON
DOLORES
SAN JUAN



GENERALIZED

LAND OWNERSHIP STATUS

(STATUS AS OF 1965)

UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

LAND OWNERSHIP AND ADMINISTRATIVE STATUS, 1965, UPPER COLORADO REGION

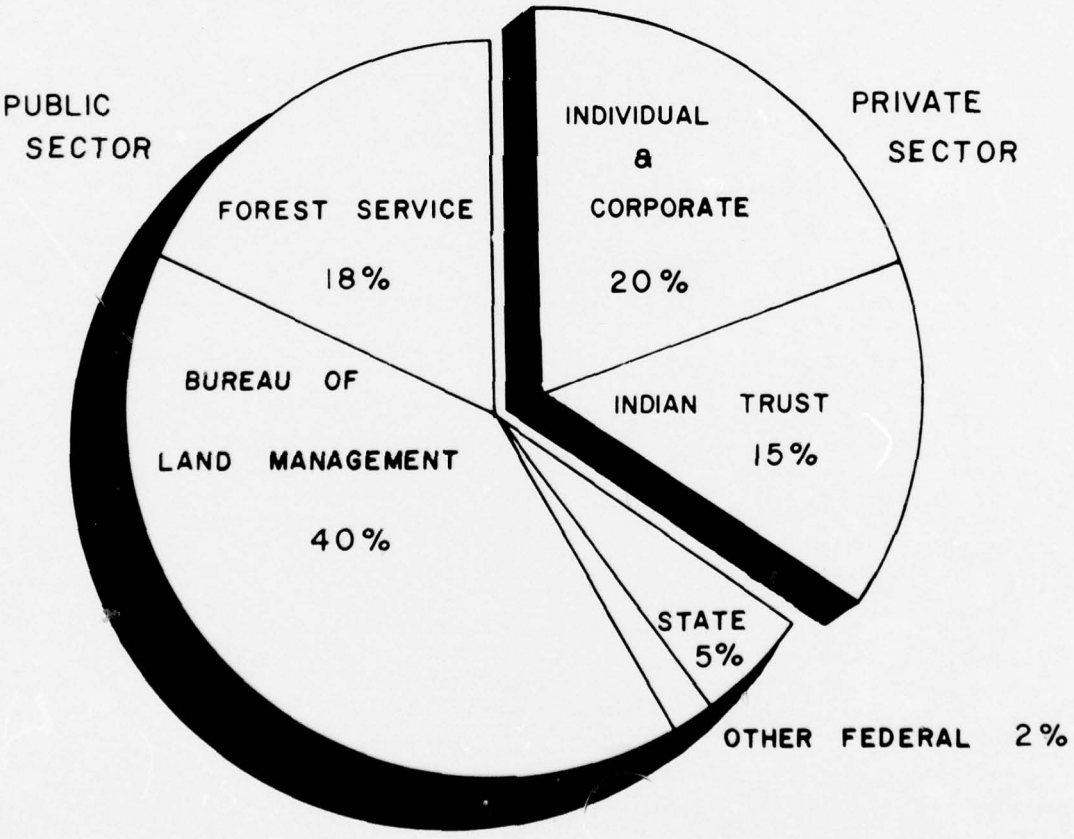


Table 5 - Land ownership and administration status by states, 1965, Upper Colorado Region

	Ari-zona	Colo-rado	New Mexico	Utah	Wyo-ming	Total
	(thousands of acres)					
	Public Sector					
Department of Agriculture						
Forest Service	6	8,410	165	3,616	1,130	13,327
Department of Interior						
Bureau of Land Management	261	6,840	1,357	12,656	7,861	28,975
Bureau of Sport Fisheries and Wildlife	0	1	0	10	12	23
National Park Service	84	340	21	410	0	855
Bureau of Reclamation	0	26	9	83	45	163
Other USDI agencies	0	1	113	0	0	113
Subtotal	345	7,207	1,501	13,158	7,918	30,129
Department of Defense	0	55	0	59	0	114
Other Federal	0	26	0	0	0	26
Total - Federal	351	15,699	1,666	16,834	9,048	43,598
State	22	465	254	1,864	951	3,556
	Private Sector					
Private, county, and municipal	12	7,666	416	2,890	3,366	14,350
Indian Trust	4,036	752	3,882	2,060	0	10,730
Total land	4,421	24,582	6,218	23,648	13,365	72,234
Water (areas > 40 acres)	12	86	16	203	88	405
Total	4,433	24,668	6,234	23,851	13,453	72,639

Table 6 - Land ownership and administration status
by subregions, 1965, Upper Colorado Region

	Green River subregion	Upper Main Stem subregion	San Juan-Colorado subregion	Region total
	(thousands of acres)			
	Public Sector			
Department of Agriculture				
Forest Service	4,424	6,218	2,685	13,327
Department of Interior				
Bureau of Land Management	15,227	5,293	8,455	28,975
Bureau of Sport Fisheries and Wildlife	22	1	0	23
National Park Service	288	296	271	855
Bureau of Reclamation	116	16	31	163
Other USDI Agencies	0	0	113	113
Subtotal	15,653	5,606	8,870	30,129
Department of Defense	59	55	0	114
Other Federal	0	26	0	26
Total - Federal	20,137	11,905	11,556	43,598
State	2,091	416	1,049	3,556
	Private Sector			
Private, county, and municipal	7,921	4,380	2,049	14,350
Indian Trust	853		9,877	10,730
Total land	31,002	16,701	24,531	72,234
Water (areas > 40 acres)	141	63	201	405
Total	31,143	16,764	24,732	72,639

Table 7 - Estimated acreage of irrigation soil classes, Upper Colorado Region

	Irrigation soil class					Nonirrigation soil class	
	A	B	C	D	Total A-D	E	Total
	(Thousands of acres)						
Green River							
Colorado	66	736	426	714	1,942	4,811	6,753
Utah	79	290	244	188	801	10,083	10,884
Wyoming	1,206	1,812	120	2,327	5,465	7,900	13,365
Subtotal	1,351	2,838	790	3,229	8,208	22,794	31,002
Upper Main Stem							
Colorado	143	1,052	693	2,040	3,928	10,200	14,128
Utah	26	105	83	22	236	2,337	2,573
Subtotal	169	1,157	776	2,062	4,164	12,537	16,701
San Juan-Colorado							
Arizona	41	265	285	162	753	3,668	4,421
Colorado	19	796	39	559	1,413	2,288	3,701
New Mexico	74	1,070	787	589	2,520	3,698	6,218
Utah	21	190	155	91	457	9,734	10,191
Subtotal	155	2,321	1,266	1,401	5,143	19,388	24,531
Region total	1,675	6,316	2,832	6,692	17,515	54,719	72,234

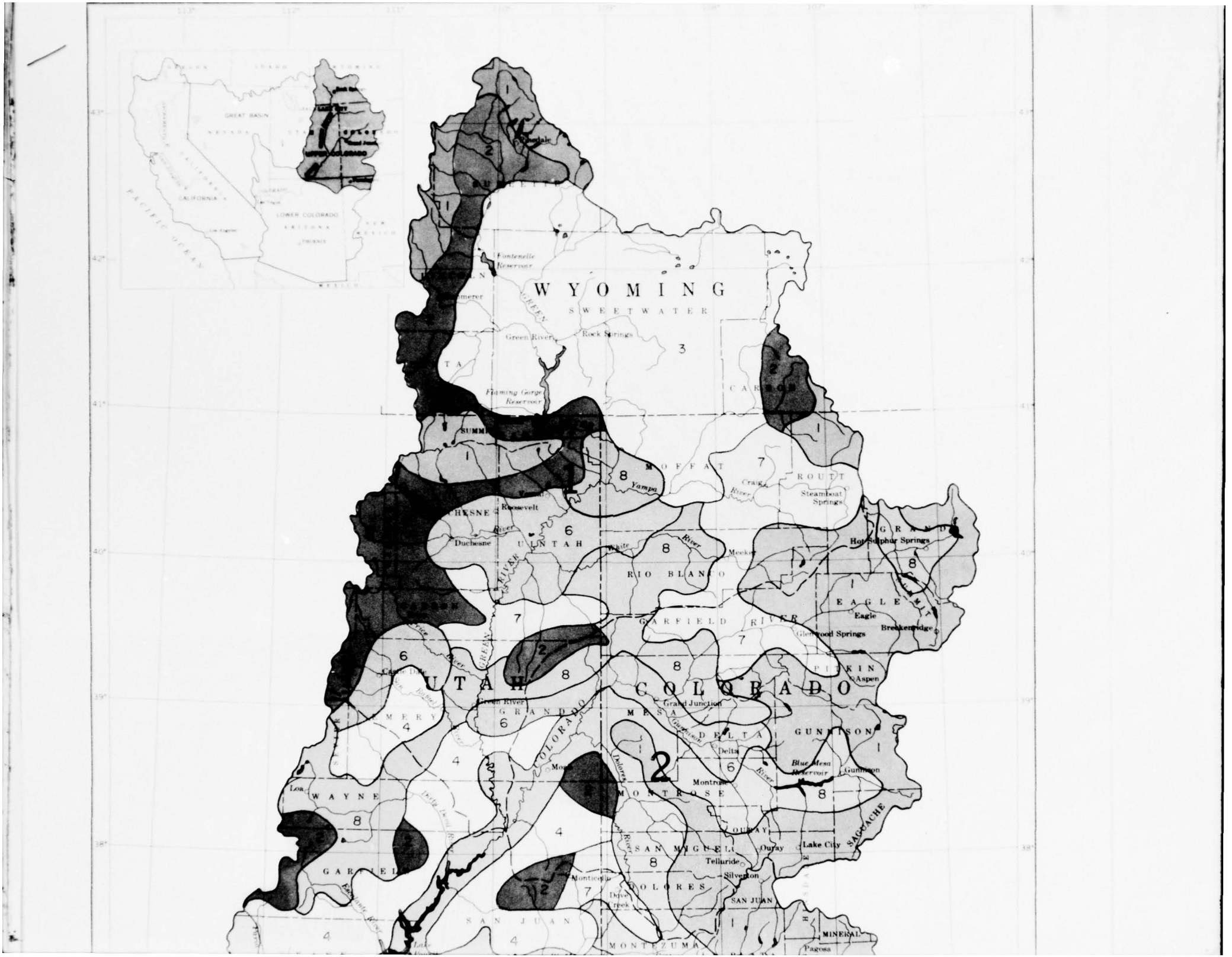
Irrigation soil classes:
- A - None to slight soil limitations.
- B - Moderate soil limitations.
- C - Severe soil limitations.
- D - Very severe soil limitations.

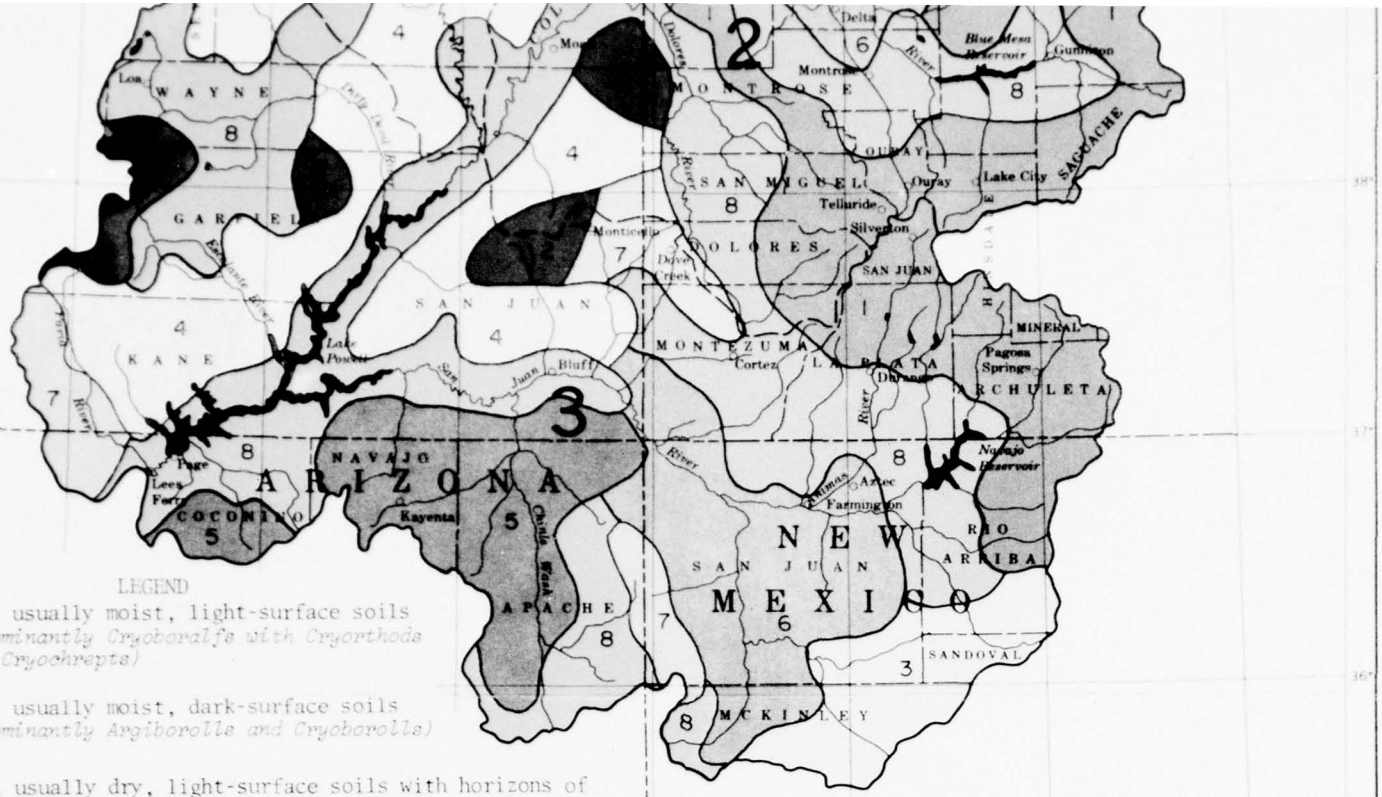
The tabulation of soils according to irrigation soil class is based on characteristics that influence suitability for sustained use under irrigation. Irrigation soil classes provide a base for conversion to irrigation land classes through application of further constraints related primarily to their occurrence in economical size units and consideration of land and water development.

Summary of Land Use by Land Resource Group

Land resource groups by states and subregions are summarized in Tables 8 and 9, and vegetal cover is shown on subregional maps following page 28 to indicate the intrinsic suitability of the area for use. The categories of urban and barren, although not vegetal in nature, are included to complete the totals for the tabulations. Vegetal cover data are presented to make the distinction from present land use and to indicate the use potential of the land.

Tables 10 and 11 summarize the present land uses by land resource groups.


WYOMING
SWEETWATER
Fontenelle Reservoir
Green River
Rock Springs
Flaming Gorge Reservoir
MOFFAT
ROUTT
Craig
Steamboat Springs
Yampa
Roosevelt
Duchesne
UINTAH
White River
Meeker
RIO BLANCO
GRAND
Hot Sulphur Springs
EAGLE
Eagle
Breckenridge
GARFIELD
Glenwood Springs
PITKIN
Aspen
UTAH
COLORADO
Grand Junction
MESA
DELTA
Delta
GUNNISON
Blue Mesa Reservoir
Gunnison
Montrose
MONTROSE
WAYNE
OURAY
Ouray
Lake City
SAGUACHE
SAN MIGUEL
Telluride
Silverton
Monticello
DOLORES
SAN JUAN
MINERAL
Pagosa
MONTEZUMA
GREAT BASIN
LOWER COLORADO
CALIFORNIA
ARIZONA
NEVADA
PACIFIC OCEAN
MEXICO



GENERAL SOIL MAP

Adapted by Land Use and Management Work Group From National Atlas Soils Compiled by the Soil Conservation Service and Published by U.S.D.I. Geological Survey 1969

UPPER COLORADO REGION
COMPREHENSIVE FRAMEWORK STUDY

GPO 851-892

Table 8 - Land resource groups by states,
1965, Upper Colorado Region

Land resource groups	Ari-zona	Colo-rado	New Mexico	Utah	Wyo-ming	Total
	(thousands of acres)					
Alpine	0	1,048	0	85	196	1,329
Forest						
Coniferous forest	99	5,146	319	2,097	634	8,295
Hardwood forest		2,296	10	718	158	3,182
Pinon-juniper woodland	746	4,198	1,440	6,008	179	12,571
Mountain brush		2,314	2	845	172	3,333
Subtotal	845	13,954	1,771	9,668	1,143	27,381
Range						
Grass and forbs	1,635	1,578	2,908	2,554	866	9,541
Northern desert shrub	187	4,483	994	3,105	8,881	17,650
Salt desert shrub	1,109	897	379	4,400	1,647	8,432
Southern desert shrub	200	90		1,587		1,877
Subtotal	3,131	7,048	4,281	11,646	11,394	37,500
Cropland and pasture	11	1,613	69	555	324	2,572
Urban	19	164	20	80	85	368
Barren and other	412	718	54	1,584	205	2,973
Water (areas < 40 acres)	3	37	23	30	18	111
Total land	4,421	24,582	6,218	23,648	13,365	72,234
Water (areas > 40 acres)	12	86	16	203	88	405
Total	4,433	24,668	6,234	23,851	13,453	72,639

Table 9 - Land resource group by subregions, Upper Colorado Region

Land resource group	Green River subregion	Upper Main Stem subregion	San Juan-Colorado subregion	Region total
	(thousands of acres)			
Alpine	354	805	170	1,329
Forest				
Coniferous forest	2,894	3,478	1,923	8,295
Hardwood forest	1,112	1,558	512	3,182
Pinon-juniper woodland	3,549	3,189	5,833	12,571
Mountain brush	1,326	1,746	261	3,333
Subtotal	8,881	9,971	8,529	27,381
Range				
Grass and forbs	2,612	878	6,051	9,541
Northern desert shrub	13,017	2,284	2,349	17,650
Salt desert shrub	3,960	1,050	3,422	8,432
Southern desert shrub	86	107	1,684	1,877
Subtotal	19,675	4,319	13,506	37,500
Cropland and pasture	970	828	774	2,572
Urban	156	132	80	368
Barren and other	924	630	1,419	2,973
Water (areas < 40 acres)	42	16	53	111
Total	31,002	16,701	24,531	72,234
Additional water (areas > 40 acres)	147	63	201	405
Total	31,149	16,764	24,732	72,639

UPPER COLOR

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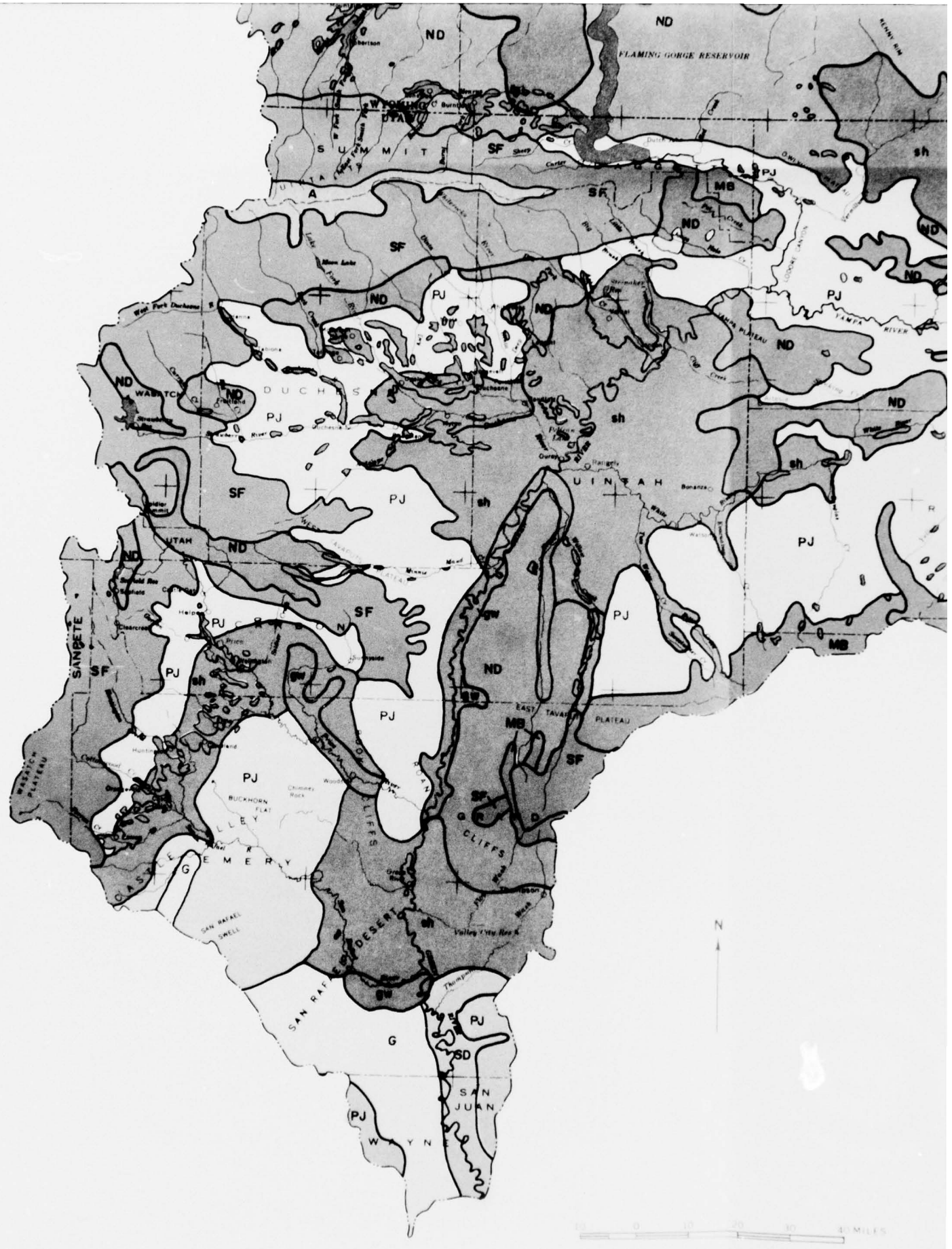
GREEN RIVE

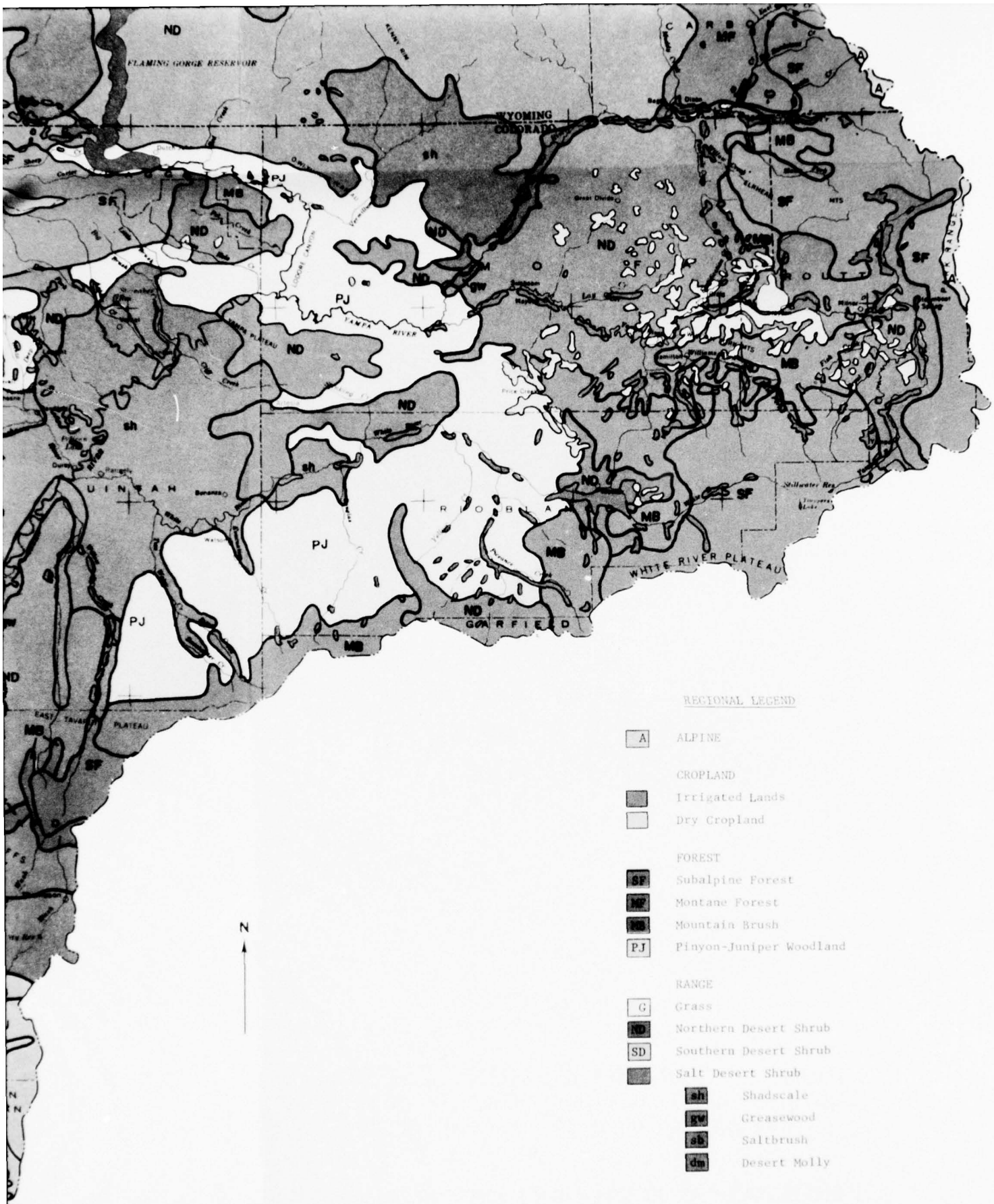
UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY
GREEN RIVER SUBREGION

SAND DUNES
SUBLETTE
FLAT
FREMONT
GREEN DIVIDE BASIN
RED DESERT BASIN
Rock Springs
Bitter Creek
Wamsutter
SWEETWATER
FLAMING GORGE RESERVOIR
WYOMING
COLORADO
Great Divide
Baggs
Dixon
ELKHEAD MTS
PARK RANGE
LODORE CANYON
YAMPA RIVER
ROUTT



Modified by the Land Use and Management Work Group from Professional Paper 441 U.S.G.S. 1965



VEGETAL COVER TYPES

with

Irrigated Lands & Dry Cropland

4

GPO 855-315

UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

GREEN RIVER SUBREGION

VEGETAL COVER TYPES

with

Irrigated Lands & Dry Cropland

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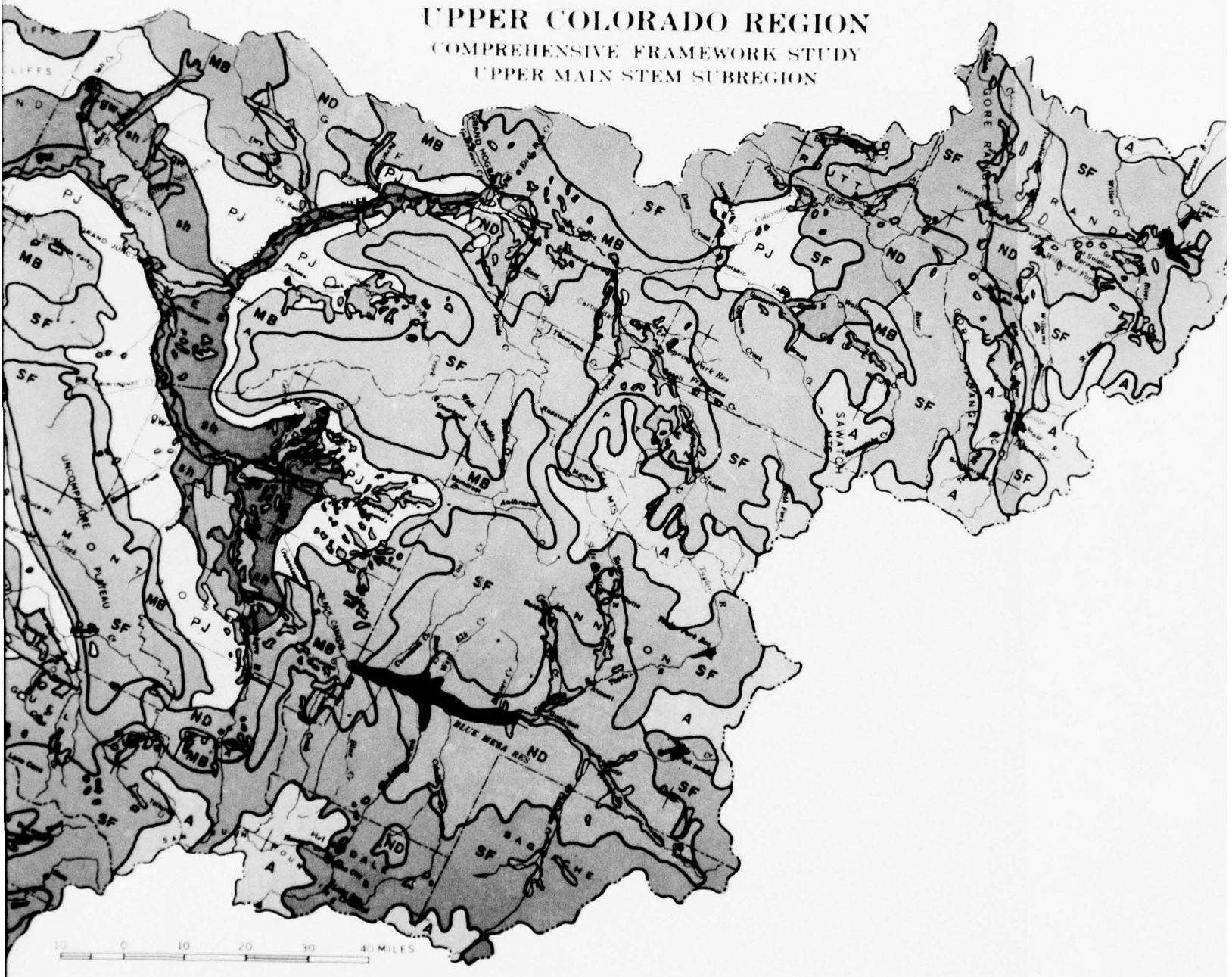
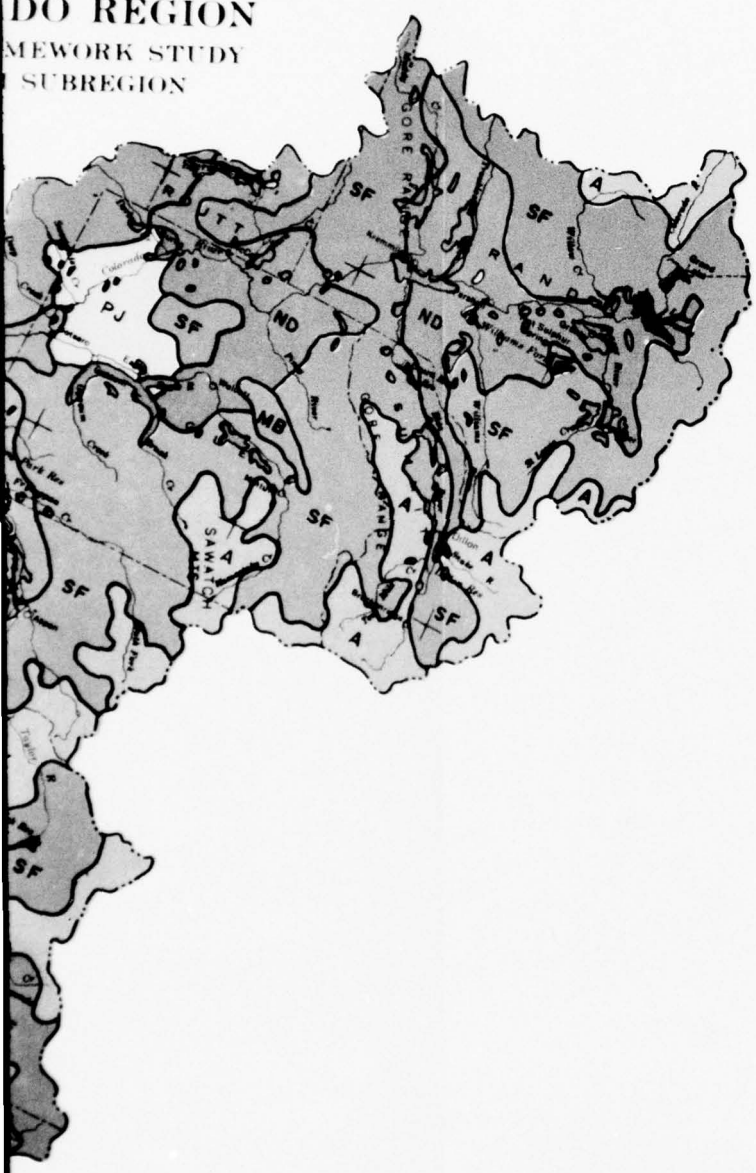
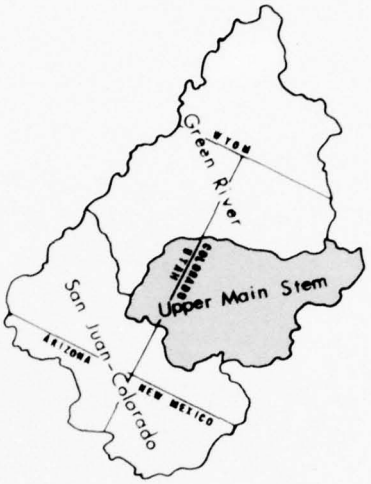
UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY
UPPER MAIN STEM SUBREGION







REGIONAL LEGEND

A	ALPINE
	CROPLAND
	Irrigated Lands
	Dry Cropland
	FOREST
SF	Subalpine Forest
MF	Montane Forest
MB	Mountain Brush
PJ	Pinyon-Juniper Woodland
	RANGE
G	Grass
ND	Northern Desert Shrub
SD	Southern Desert Shrub
	Salt Desert Shrub
	Shadscale
	Greasewood
	Saltbrush
	Desert Molly

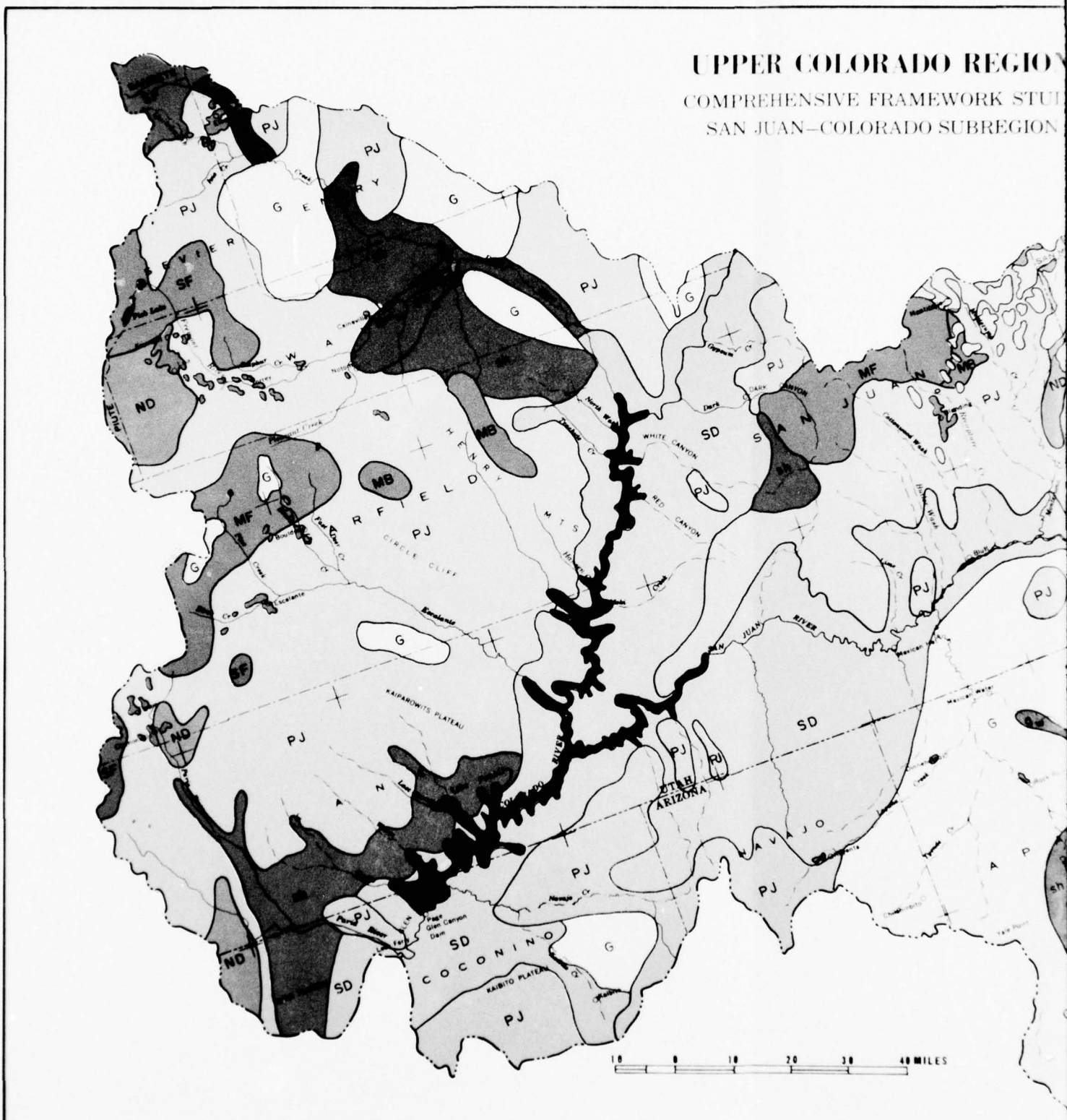
VEGETAL COVER TYPES

with

Irrigated Lands & Dry Cropland

GPO 855-142

3



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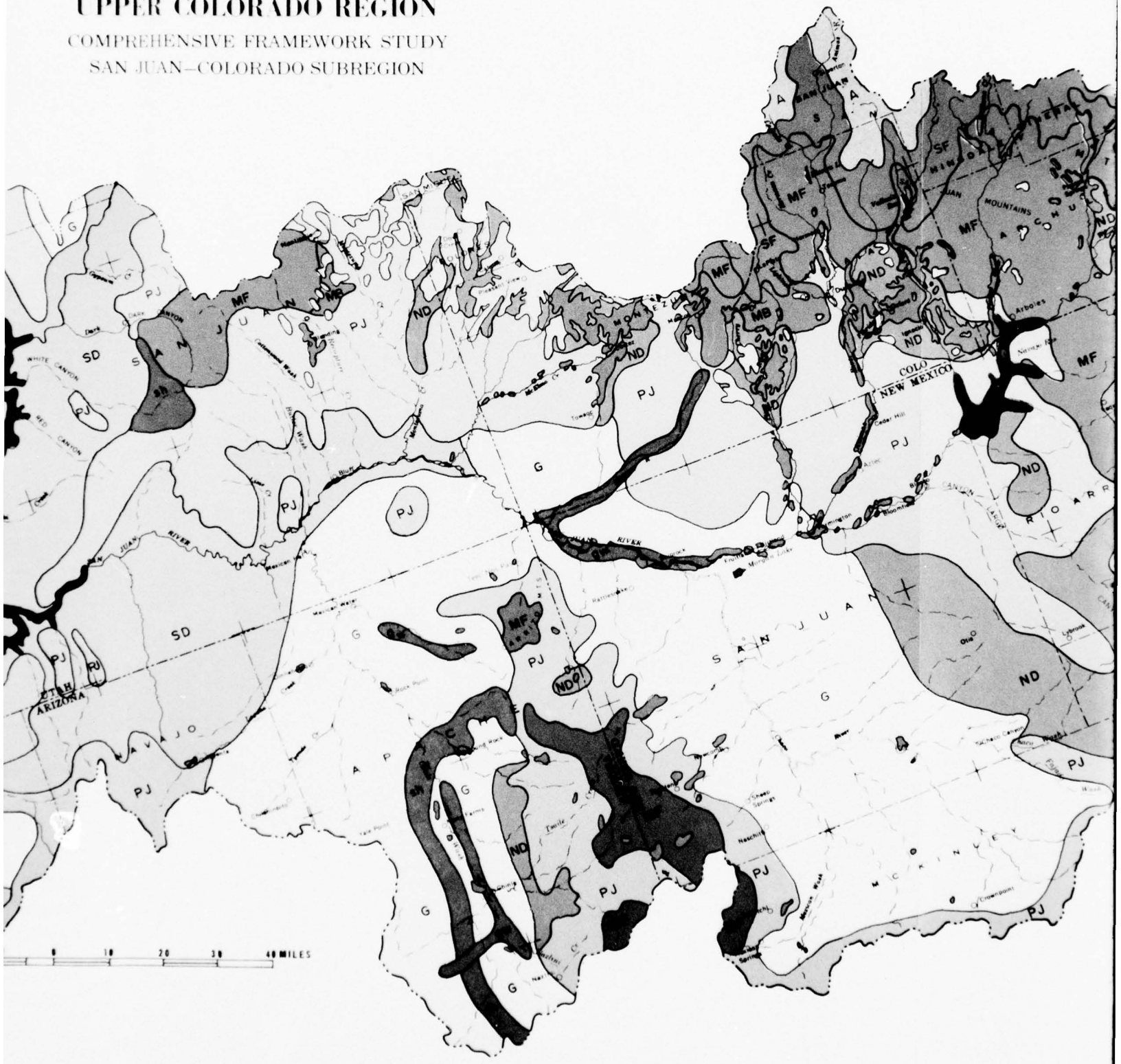
UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

SAN JUAN–COLORADO SUBREGION



VEGETAL COVER TYPES

with

Irrigated Lands & Dry Cropland

GPO 855 - 143

3

Table 10. Land use region and Green River Subregion, 1965, Upper Colorado Region

Land Resource Groups	Area	Cropland		Grazing	Timber Production	Urban and Industrial	Developed Recreation	Primitive Areas (Wilderness)	Developed Mineral Production	Trans. and Utilities	Developed Fish and Wildlife	Military	Classified Watershed
		Irrigated	Dry										
		Area (Thousands of Acres)											
UPPER COLORADO REGION													
Alpine	1,329	-	-	342	-	3	1	417	-	6	-	-	22
Forest	27,381	-	-	21,988	9,419	4	3	777	-	98	-	12	155
Range	37,500	-	-	36,534	-	7	3	156	-	142	-	101	68
Cropland	1,506	963	543	-	-	-	-	-	-	-	-	-	-
Pasture	1,066	659	60	347	-	-	-	-	-	-	-	-	-
Urban (Private)	368	-	-	-	-	177	-	-	-	191	-	-	-
Water 1/ and miscellaneous	3,084	-	-	1,231	-	140	64	64	37	161	299	1	13
Total land	72,234	1,622	603	60,442	9,419	331	71	1,414	37	598	299	114	258
Water (areas > 40 ac.)	405	-	-	-	-	-	339	-	-	-	-	-	-
TOTAL	72,639	1,622	603	60,442	9,419	331	410	1,414	37	598	299	114	258
GREEN RIVER SUBREGION													
Alpine	354	-	-	42	-	-	-	224	-	2	-	-	22
Forest	8,881	-	-	7,322	2,900	1	1	499	-	22	-	12	122
Range	19,675	-	-	19,426	-	4	1	37	-	104	-	46	36
Cropland	580	416	164	-	-	-	-	-	-	-	-	-	-
Pasture	390	296	27	67	-	-	-	-	-	-	-	-	-
Urban (Private)	156	-	-	-	-	70	-	-	-	86	-	-	-
Water 1/ and miscellaneous	966	-	-	362	-	45	16	-	9	53	161	1	-
Total land	31,002	712	191	27,219	2,900	120	18	760	9	267	161	59	180
Water (areas > 40 ac.)	141	-	-	-	-	-	84	-	-	-	-	-	-
TOTAL	31,143	712	191	27,219	2,900	120	102	760	9	267	161	59	180

Note: Horizontal totals may exceed the total land area because of overlapping uses. Extensive uses such as incidental recreation, fishing, hunting, and wildlife habitat are not identified in this table. Timber production acreage for economic subregions.

1/ 111,000 surface acres of water such as streams less than 1/8 mile wide and lakes or reservoirs less than 40 acres in Upper Colorado Region; 42,000 acres in Green River Subregion.

Table 11. Land use Upper Main Stem and San Juan-Colorado Subregion, 1965, Upper Colorado Region

Land Resource Groups	Area	Cropland		Grazing	Timber Production	Urban and Industrial	Developed Recreation	Primitive Areas (Wilderness)	Developed Mineral Production	Trans. and Utilities	Developed Fish and Wildlife	Military	Classified Watershed
		Irrigated	Dry										
		Area (Thousands of Acres)											
UPPER MAIN STEM SUBREGION													
Alpine	805	-	-	300	-	1	1	129	-	3	-	-	-
Forest	9,971	-	-	6,971	4,538	-	1	186	-	44	-	-	33
Range	4,319	-	-	4,220	-	1	1	15	-	21	-	55	31
Cropland	457	386	71	-	-	-	-	-	-	-	-	-	-
Pasture	371	233	8	130	-	-	-	-	-	-	-	-	-
Urban (Private)	132	-	-	-	-	63	-	-	-	69	-	-	-
Water 1/ and miscellaneous	646	-	-	188	-	81	28	37	11	90	53	-	13
Total land	16,701	619	79	11,809	4,538	146	31	367	11	227	53	55	77
Water (areas > 40 ac.)	63	-	-	-	-	-	48	-	-	-	-	-	-
TOTAL	16,764	619	79	11,809	4,538	146	79	367	11	227	53	55	77
SAN JUAN-COLORADO SUBREGION													
Alpine	170	-	-	-	-	2	-	64	-	1	-	-	-
Forest	8,529	-	-	7,695	1,981	3	1	92	-	32	-	-	-
Range	13,506	-	-	12,888	-	2	1	104	-	17	-	-	1
Cropland	469	161	308	-	-	-	-	-	-	-	-	-	-
Pasture	305	130	25	150	-	-	-	-	-	-	-	-	-
Urban (Private)	80	-	-	-	-	44	-	-	-	36	-	-	-
Water 1/ and miscellaneous	1,472	-	-	681	-	14	20	27	17	18	85	-	-
Total land	24,531	291	333	21,414	1,981	65	22	287	17	104	85	-	1
Water (areas > 40 ac.)	201	-	-	-	-	-	201	-	-	-	-	-	-
TOTAL	24,732	291	333	21,414	1,981	65	223	287	17	104	85	-	1

Note: Horizontal totals may exceed the total land area because of overlapping uses. Extensive uses such as incidental recreation, fishing, hunting, and wildlife habitat are not identified in this table. Timber production acreage for economic subregions.

1/ 16,000 surface acres of water such as streams less than 1/8 mile wide and lakes or reservoirs less than 40 acres. in Upper Main Stem Subregion; 53,000 acres in San Juan-Colorado Subregion.

PART III

REGIONAL NEEDS AND DEMANDS

The regional needs and demands are based primarily on the regional interpretation of the OBERS projections for the time frames of 1980, 2000, and 2020. Principal indices include production of assigned agricultural and industrial commodities within the region and development of resources to meet demands generated in adjacent areas. Major items to respond to demands from outside the region include the production of meat animals and timber products, mining and processing of minerals, generation of hydro- and thermal-electric power, and further development of facilities at scenic and recreational sites to accommodate the large numbers of visitors who look to the region as a desirable vacation area.

Studies of needs and demands were based in part upon the March 1968 OBE population data as these were the only projections available when detailed studies started. Adjustment was made by adding the hydrologic area of Arizona contained in the Upper Colorado Region. Table 12 shows a summary of the population projections.

Table 12 - Population estimates, Upper Colorado Region

Subregion and states	1965	1980	2000	2020
March 1968 OBE projections with Arizona portion added (Economic subregions other than Arizona)				
Green River	100,579	107,100	124,400	151,200
Upper Main Stem	136,725	142,900	171,400	204,200
San Juan-Colorado	128,725	176,200	241,900	324,800
Region	366,029	426,200	537,700	680,200
Arizona	29,100	41,700	52,300	64,300
Colorado	186,450	205,400	252,800	313,900
New Mexico	46,600	65,000	95,000	125,000
Utah	65,100	74,500	94,100	124,100
Wyoming	38,779	39,600	43,500	52,900
Region	366,029	426,200	537,700	680,200

Major demands exist outside the region for water produced within the Upper Colorado Region. A large amount of the available water is committed to downstream delivery or transferred to the Great Basin, Missouri, Arkansas-White-Red, and Rio Grande Regions under terms of the

compacts, treaties, and laws which govern the operation of the Colorado River system.

This part includes:

(1) Summary of estimated water needs in terms of on-site depletions from the stream system, including the transmountain diversions.

(2) Related land needs summary where data were available in quantitative terms.

(3) Summary requirements of major functions.

Water Needs in Terms of On-site Depletions

By the year 2020 there would be on-site depletion needs of 6.55 million acre-feet. The largest consumptive use need, which is 50.5 percent of the total in 2020 or 3.29 million acre-feet, is for irrigated crops, associated seeped and phreatophyte areas incident to irrigation and irrigation reservoir evaporation.

Other water needs in 2020 are in municipal and industrial water supply (1.3 percent), minerals (0.8 percent), augmented fish and wildlife and recreation (1.4 percent), stock-pond evaporation and livestock use (0.9 percent), and thermal-electric power generation (9.7 percent). About 1.65 million acre-feet or 25.3 percent of the 2020 depletion would be exported. Main-stem regulating reservoir evaporation would account for 10.1 percent or 660,000 acre-feet of depletion. Table 13 presents stream depletions for the five states and three subregions by types of needs for 1980, 2000, and 2020.

It was agreed that the year 2020 depletion distributions would reflect the states' percentages shown in the Upper Colorado River Basin Compact.

Explanatory notes on these water depletions follow.

Municipal and industrial

Depletions by domestic, manufacturing, governmental, commercial, and other related purposes for 2020 total 110,100 acre-feet, with approximate category use as follows: domestic - 43,100 acre-feet, manufacturing - 12,700 acre-feet, governmental - 8,800 acre-feet, and commercial - 45,500 acre-feet.

Thermal-electric power

The 2020 water depletion by steam-electric generation plants is estimated at 626,600 acre-feet. Principal consumptive use is for condenser

cooling purposes. Power production by 2020 by states and for the region is estimated as follows: Arizona - 2,310 MW, Colorado - 16,976 MW, New Mexico - 7,123 MW, Utah - 5,759 MW, Wyoming - 9,913 MW, Region - 42,081 MW.

Minerals

Projections of mineral production totaling $2,014 million would deplete about 52,800 acre-feet of water.

Augmented fish and wildlife

The projected consumptive use comprises 127,400 acre-feet from the fish and wildlife facilities which will be required to satisfy future demand. This total represents 11,700 acre-feet of on-site depletions occurring in 1965 plus amounts of 88,000 acre-feet needed for waterfowl and 27,700 acre-feet needed for fish by the year 2020 (Table 26). The consumptive use is based on depletions from 51,200 surface acres of facilities intended primarily for fish and wildlife. It is reasonable to suppose, however, that multipurpose facilities, not yet planned or authorized, may become available to meet part of this future demand.

Water-supply restrictions based on compact limitations for those parts of Arizona and New Mexico in the Upper Colorado Region will become a major problem in attaining the future development needed in this part of the region. For the purpose of this study, fish and wildlife water need at the year 2020 has been reduced from 12,200 acre-feet to 1,200 acre-feet for Arizona and from 35,300 acre-feet to 6,800 acre-feet for New Mexico (Table 13). There may be a possibility of obtaining additional water in future years through the recommitment of undeveloped water or the purchase and transfer of water developed for other purposes.

Recreation

The amount of consumptive water need in 2020 would be 5,200 acre-feet, most of which would be used at associated service facilities. The rate of consumptive use would be 7.7 gallons per recreation day for the projected 236 million recreation days by 2020, of which less than 3 percent would be by residents of the region.

Stock-pond evaporation and livestock use

Stock-pond evaporation from 38,000 man-made stock ponds in 2020 is estimated to be 41,000 acre-feet annually. Livestock water use by 2020 computed at 10 gallons per day per animal unit for 1.6 million cattle animal units is estimated to be 18,000 acre-feet.

Irrigation

On-site depletion by 2020 on 2.122 million acres of irrigated cropland, incidental use on water-consuming noncropped areas, and irrigation

Table 11 - Water needs - reasonably interpreted (RIP) level of development, Upper Colorado region

Type of use	Co-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Upper Basin	Lower Basin	Mainstem reservoirs
					1980				
Municipal and industrial	2,900	22,100	1,900	7,800	4,300	43,000	11,700	16,200	15,100
Electric power (thermal)	34,100	26,700	55,700	50,400	33,200	200,100	72,300	1,300	125,500
Minerals	400	19,500	3,700	10,300	19,000	52,900	11,500	33,700	7,700
Fish and wildlife	1,200	38,800	6,800	22,200	18,800	87,800	49,400	7,900	30,500
Recreation	100	600	100	1,000	200	2,000	800	600	600
Stock-pond evaporation and livestock use	1,400	25,000	2,400	7,300	4,800	41,400	17,300	13,700	10,400
Subtotal	40,100	132,700	75,100	99,000	80,300	427,200	181,200	53,900	190,100
Irrigation: consumptive use, incidental use, and reservoir evaporation	7,000	1,479,000	245,000	588,000	334,000	2,653,000	955,500	1,078,000	591,000
Export		719,000	117,500	190,000	65,000	1,091,500	255,000	716,000	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,330,700	437,600	874,400	479,300	4,169,100	1,420,200	1,847,900	901,000
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,829,100	1,487,200	1,864,900	1,477,000
					2000				
Municipal and industrial	4,800	34,300	10,600	12,100	5,900	67,700	16,900	24,900	25,900
Electric power (thermal)	34,100	254,600	106,800	86,400	148,700	630,600	393,500	24,200	212,900
Minerals	300	19,900	3,900	10,300	22,100	56,500	32,000	16,700	7,800
Fish and wildlife	1,200	38,800	6,800	22,200	18,700	87,800	49,400	7,900	30,500
Recreation	300	1,000	100	1,600	200	3,200	1,300	900	1,000
Stock-pond evaporation and livestock use	1,700	30,500	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	379,100	131,900	141,600	201,500	896,100	511,300	91,700	293,100
Irrigation: consumptive use, incidental use, and reservoir evaporation	7,600	1,633,000	329,000	605,000	407,000	2,981,600	1,062,000	1,166,000	753,600
Export		883,000	117,500	437,000	150,000	1,587,500	587,000	880,000	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	2,895,100	578,000	1,181,000	758,500	5,462,600	2,160,300	2,137,700	1,164,600
Main-stem reservoir evaporation						660,300	67,000	17,000	576,300
Total for 2000						6,122,600	2,227,300	2,154,700	1,740,600
					2020				
Municipal and industrial	7,200	56,000	17,300	20,400	9,200	110,100	26,400	40,400	43,300
Electric power (thermal)	30,100	254,600	106,800	86,400	148,700	626,600	393,500	24,200	208,900
Minerals	300	17,000	2,600	11,400	21,500	52,800	26,400	20,800	5,600
Fish and wildlife	1,200	38,800	6,800	22,200	18,800	87,800	49,400	7,900	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stock-pond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	403,800	137,700	153,700	205,300	941,500	519,100	115,200	307,200
Irrigation: consumptive use, incidental use, and reservoir evaporation	9,000	1,723,000	411,000	723,000	428,000	3,294,000	1,147,000	1,233,000	914,000
Export		883,000	117,500	467,000	185,000	1,652,500	652,000	880,000	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,009,800	666,200	1,341,100	818,300	5,885,400	2,318,100	2,228,200	1,339,100
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						6,545,400	2,385,100	2,245,200	1,915,100

reservoir evaporation would total 3.29 million acre-feet annually. An increase of about 500,600 acres of new full supply cropland would be required between 1965 and 2020 to meet feed and food production projections. Of the 549,300 acres of presently short supply land, 421,100 acres would need supplemental water to obtain full production.

Irrigation consumptive use by 2020, including supplemental water, would total 2,707,000 acre-feet. Irrigation reservoir evaporation would be about 187,000 acre-feet. Incidental use is estimated to increase from the present 315,600 acre-feet (18.6 percent of the total) to about 400,000 acre-feet (14.8 percent) by 2020.

Export by transmountain diversions

Water export needs generated by adjacent regions total 1.65 million acre-feet of water by 2020. Wyoming's export of 185,000 acre-feet would be to the urban areas of Cheyenne-Laramie and to the North Platte River. Colorado would export 883,000 acre-feet to the Fort Collins-Denver-Colorado Springs area for municipal, industrial, and agricultural use and to the Arkansas and Rio Grande systems. Utah would export 467,000 acre-feet to the Great Basin for municipal, industrial, and agricultural use. New Mexico would export 110,000 acre-feet to the Rio Grande by 1980 and an additional 7,500 acre-feet for municipal use at Gallup, located in the Lower Colorado Region.

Import

A small import from the Great Basin to the Paria River is expected to remain at the present level of 2,600 acre-feet annually.

Main-stem reservoir evaporation

Evaporation loss in 2020 from the five main-stem regulating reservoirs (Lake Powell, Flaming Gorge, Blue Mesa, Morrow Point, and Crystal) for normal operating conditions would be 660,000 acre-feet annually. It should be noted, however, that evaporation losses would only be charged against the separate states at such time as curtailment of water deliveries (because of compact provisions) is required in the region.

Land Needs Summary

The regional needs, including 1965 use for land resources, summarized by principal land use, are shown in Table 14.

Table 14 - Multiple land needs - regionally interpreted OBERS level of development, Upper Colorado Region

Principal use1/	1965	1980	2000	2020	Change 1965 to 2020
	(thousands of acres)				
Cropland and pasture					
Irrigated	1,622	1,794	1,954	2,122	+500
Dry	603	572	532	503	(-)100
Livestock grazing	60,442	55,958	54,691	53,380	(-)7,062
Timber production	9,419	9,351	9,266	9,194	(-)225
Urban and industrial	331	356	403	471	+140
Transportation and utilities	598	632	703	788	+190
Developed recreation	71	140	273	506	+435
Developed fish and wildlife	299	393	450	508	+209
Wilderness, natural, historic, and cultural	2,636	(See narrative)			
Developed mineral production	37	71	103	178	+141
Military	114	114	114	114	0
Classified watersheds	258	262	268	271	+13
Water (area > 40 acres)	405	482	493	514	+109

1/ Multiple uses of the land are made in most categories shown.

Irrigated cropland

There were 1,621,500 acres of irrigated land in 1965. It is estimated that an increase of 500,600 acres to a total of 2,122,100 acres of irrigated land would be required to meet regional needs by the year 2020. An additional 86,800 acres of new land will be required to replace irrigated land diverted to other uses.

Dry cropland

There were 603,400 acres of dry cropland being farmed in 1965. It is estimated that approximately 100,000 acres of dry cropland would be required for new irrigated land, urban, and other uses by 2020. Dry cropland acreage would decrease as there are virtually no new areas that are considered suitable for dryfarming.

Livestock grazing

Livestock grazed 84 percent or 60.4 million of the 72.2 million acres of land in 1965. Grazing should be retired on about 5.8 million acres of unsuitable land. Approximately 1.3 million acres of the remaining acreage would be required for other uses under the RI OBERS and the remaining 53.4 million acres would be needed for livestock grazing. This need would not be for exclusive use except in isolated instances or for short periods of time.

Timber production

Present timber production of 47.8 million cubic feet should be increased by 292.2 million cubic feet annually by 2020 although projections indicate commercial forest acreage would be reduced a minimum of 225,000 acres.

Urban, industrial, transportation, and utilities

Future land need for expansion of urban and industrial uses would require 140,000 acres and transportation and utilities uses would require about 190,000 acres by 2020.

Recreation

Expansion of developed recreational facilities to accommodate an increase of 169 million recreation days would require 435,000 more acres of land by 2020. Recreation use on almost all other lands would be greatly intensified.

Developed fish and wildlife

Fishing and hunting facilities would be needed on an additional 209,000 acres.

Wilderness, natural, historic, and cultural

The 2,636,000 acres reported for these categories include all areas in the region that were designated in the Wilderness Act, Tribal and BLM lands that are managed in accordance with the intent of this legislation, and areas presently designated as having significant natural features, or

with historic or cultural importance. These needs apply only to recreational Classes IV, V, and VI lands.

Needs for additional lands to be managed for this purpose have not been projected, even though many more acres still exist that have this potential but have not yet been officially designated. It must be recognized that these areas are diminishing. Wilderness areas are especially unique because they are difficult to recreate once their pristine nature has been altered. Increased wilderness areas are desirable and will be required to meet regional and national needs. Studies at an early date are needed to identify outstanding natural wilderness areas and to integrate these into the wilderness system.

Developed minerals

Land requirements would increase from 37,000 to 178,000 acres.

Military

Military and related land use was assumed to remain at the 1965 level throughout the 1965-2020 period.

Classified watersheds

Land managed for watershed protection totaling 258,000 acres are used primarily for municipal water supplies and will probably remain at this level. A specific requirement of 13,000 acres for flood control structures was included in this category.

Water areas

About 109,000 additional acres would be required for the construction of 200 new reservoirs. These reservoirs include 90 for irrigation, 9 for export regulation and exchange, 3 for thermal-power generation, about 30 for municipal and industrial, and over 100 for fish and wildlife. Most reservoirs are multipurpose. An additional 11,000 acres of small water areas (less than 40 acres each) would be developed.

Summary Requirements of Major Functions

Requirements to meet projected needs generated by regionally interpreted OBERS are discussed by various functions.

Mineral resources

Important mineral resource developments through 1980 probably will be confined to the commodities--petroleum, uranium, coal, molybdenum,

and trona. Subsequent to that period, the mineral-commodity mix becomes more conjectural. Molybdenum and trona, having both a strong reserve footing and promise of continued market strength, seem assured of long-term orderly growth in output. Petroleum, uranium, and coal probably would dominate the mineral-fuels mix throughout the period. Phosphate and potash output should increase substantially after 1980 and, together with molybdenum and trona, should constitute the bulk metal and nonmetals production. Oil shale and other synthetic fuel developments were not projected as needs under RI OBERS.

Value of mineral production in the region is expected to increase sharply from $543 million in 1965 to $2,014 million in 2020. Water needs are projected to increase from 33,700 to 52,800 acre-feet by 2020. Anticipated land requirements expand from 37,000 to 178,000 acres, a significant 381-percent upturn. These land requirements include the surface mining spoil areas.

Value of mineral production for base year 1965 and projections for 1980, 2000, and 2020 follow:

Subregion	Value of mineral production (thousand 1958 dollars)			
	1965	1980	2000	2020
Green River	217,600	500,200	783,900	889,400
Upper Main Stem	137,800	565,300	575,000	587,500
San Juan-Colorado	187,500	467,200	525,600	537,000
Upper Colorado Region	542,900	1,532,700	1,884,500	2,014,400

Estimates of mineral industry land use in base year 1965 and 1980, 2000, and 2020 are listed below:

Subregion	Mineral industry land use (acres)			
	1965	1980	2000	2020
Green River	8,560	13,050	24,050	27,800
Upper Main Stem	11,620	12,630	14,680	15,470
San Juan-Colorado	16,600	44,980	64,040	134,660
Upper Colorado Region	36,780	70,660	102,770	177,930

Land use

There are 72.2 million acres of land within the region, most of which have some problems associated with their use. These problems and

suggested solutions are discussed subsequently. Needs are expressed by general land use categories.

Projection of production requirements for livestock products to be supported by the land base is summarized in Table 15. Table 16 lists the projected production of hay, pasture, silage, grains, and other crops from irrigated land; Table 17 shows the production from nonirrigated land and range for the projected time frames.

Irrigated Cropland

To meet regionally interpreted OBERS 587,400 acres of new irrigated land would have to be developed. This represents 500,600-acre increase in total with an additional 86,800 acres to replace presently irrigated lands converted to other uses. Water erosion damage is present on 675,000 acres of the presently irrigated land. Treatment practices required to reduce erosion include proper irrigation water management, limited tillage, installation of water control structures, and land leveling and smoothing.

An estimated 549,300 acres of irrigated cropland have a 240,000-acre-foot short water supply in an average year. In addition, it is estimated that one-half of the present idle (62,000 acres) is not farmed because irrigation water is not available in an average year. A dependable and adequate irrigation water supply is required to produce maximum yields.

State	Irrigated lands having short water supply	
	Acres	Acre-feet
	Green River	
Colorado	44,900	17,500
Utah	101,900	56,800
Wyoming	151,500	52,900
Subtotal	298,300	127,200
	Upper Main Stem	
Colorado	157,200	64,100
Utah	4,800	4,500
Subtotal	162,000	68,600
	San Juan-Colorado	
Arizona	3,500	2,200
Colorado	60,600	20,900
New Mexico	6,300	[illegible]
Utah	18,600	[illegible]
Subtotal	89,000	[illegible]
Region total	549,300	240,000

Table 15 - Projected livestock products production, regionally interpreted OBERS level of development, Upper Colorado Region[1/]

Crop and subregion	Unit	Amount in thousands			
		1965	1980	2000	2020
Beef and veal	Lbs.				
Green River		91,613	121,628	159,448	205,952
Upper Main Stem		76,919	110,663	152,415	206,655
San Juan-Colorado		38,925	49,847	63,785	80,308
Total		207,457	282,138	375,648	492,915
Pork	Lbs.				
Green River		300	230	300	395
Upper Main Stem		1,500	1,151	1,502	1,976
San Juan-Colorado		200	153	200	264
Total		2,000	1,534	2,002	2,635
Lamb and mutton	Lbs.				
Green River		45,632	47,823	63,456	83,140
Upper Main Stem		28,629	25,751	34,169	44,768
San Juan-Colorado		13,425	18,394	24,406	31,977
Total		87,686	91,968	122,031	159,885
Milk	Lbs.				
Green River		111,176	174,096	226,789	292,794
Upper Main Stem		54,364	121,867	158,752	204,956
San Juan-Colorado		27,172	52,229	68,037	87,838
Total		192,712	348,192	453,578	585,588
Eggs	No.				
Green River		12,213	14,366	18,842	24,520
Upper Main Stem		15,900	18,719	24,551	31,950
San Juan-Colorado		7,851	10,448	13,703	17,833
Total		35,964	43,533	57,096	74,303
Farm chickens	Lbs.				
Green River		150	285	360	477
Upper Main Stem		196	371	470	621
San Juan-Colorado		110	207	262	347
Total		456	863	1,092	1,445
Horses[2/]	No.				
Green River		18	20	27	37
Upper Main Stem		8	9	13	18
San Juan-Colorado		11	17	25	38
Total		37	46	65	93

1/ RI OBERS and OBERS as published are the same.
2/ Inventory of horses of all ages. Not annual production.

Table 16 - Projected production from irrigated land, regionally interpreted
OBERS level of development, Upper Colorado Region

Crop	Unit	Hydrologic subregion: Green River	Upper Main Stem	San Juan-Colorado	Region
		Year 1980			
Hay					
Alfalfa	Ton	303,971	430,996	250,727	985,694
Other hay					
Improved	Ton	86,706	59,707	17,662	164,075
Native	Ton	133,613	68,566	9,321	211,500
Subtotal		524,290	559,269	277,710	1,361,269
Pasture					
Rotation (cropland)	AUM	595,159	474,659	353,729	1,423,547
Permanent (noncropland)	AUM	227,127	173,127	75,158	475,412
Other (noncropland)	AUM	41,062	35,651	29,695	106,408
Subtotal		863,348	683,437	458,582	2,005,367
Corn silage	Ton	111,692	284,927	213,421	610,000
Feed grains					
Oats	Bu.	996,598	1,247,608	412,994	2,617,200
Barley (exclude Moravian)	Bu.	800,839	393,286	489,511	1,683,636
Corn	Bu.	43,585	1,430,725	420,690	1,895,000
Other grains					
Barley (Moravian)	Bu.	0	1,404,545	144,531	1,549,076
Wheat	Bu.	901,087	192,339	777,574	1,871,000
Other crops					
Orchard	Ton	2,950	86,760	18,290	108,000
Sugar beets	Ton	33,140	327,860	0	361,000
Dry beans	Cwt.	0	161,933	30,067	192,000
Truck crops	Cwt.	29,310	175,845	175,845	381,000
Potatoes	Cwt.	25,745	240,436	197,673	463,854
		Year 2000			
Hay					
Alfalfa	Ton	374,386	496,058	379,364	1,249,808
Other hay					
Improved	Ton	119,647	69,984	20,412	206,043
Native	Ton	148,468	76,186	10,346	235,000
Subtotal		630,498	642,228	410,125	1,690,851
Pasture					
Rotation (cropland)	AUM	907,998	740,084	651,355	2,299,437
Permanent (noncropland)	AUM	251,084	190,364	74,569	516,017
Other (noncropland)	AUM	45,331	39,196	32,727	117,244
Subtotal		1,204,413	969,644	758,651	2,932,698
Corn silage	Ton	189,238	402,497	294,265	882,000
Feed grains					
Oats	Bu.	894,198	1,046,843	332,539	2,273,000
Barley (exclude Moravian)	Bu.	848,528	602,667	790,623	2,301,818
Corn	Bu.	56,865	1,718,425	622,710	2,398,000
Other grains					
Barley (Moravian)	Bu.	0	2,277,273	369,112	2,646,385
Wheat	Bu.	1,029,376	247,135	859,489	2,136,000
Other crops					
Orchard	Ton	3,935	115,668	24,397	144,000
Sugar beets	Ton	39,550	525,450	0	565,000
Dry beans	Cwt.	0	183,160	57,840	241,000
Truck crops	Cwt.	38,463	230,769	230,768	500,000
Potatoes	Cwt.	28,973	280,218	242,837	551,928
		Year 2020			
Hay					
Alfalfa	Ton	444,800	561,120	508,000	1,513,920
Other hay					
Improved	Ton	144,588	80,260	23,162	248,010
Native	Ton	163,416	83,807	11,377	255,600
Subtotal		752,804	725,187	542,539	2,020,430
Pasture					
Rotation (cropland)	AUM	1,220,718	1,005,408	948,885	3,175,011
Permanent (noncropland)	AUM	275,040	207,600	73,980	556,620
Other (noncropland)	AUM	49,500	42,735	35,760	128,090
Subtotal		1,545,258	1,255,728	1,058,625	3,859,711
Corn silage	Ton	291,920	550,484	400,368	1,242,772
Feed grains					
Oats	Bu.	591,000	640,275	196,980	1,428,255
Barley (exclude Moravian)	Bu.	895,356	931,161	1,090,693	2,917,210
Corn	Bu.	71,900	2,074,812	833,924	2,980,636
Other grains					
Barley (Moravian)	Bu.	0	3,150,000	610,000	3,760,000
Wheat	Bu.	1,300,000	325,000	1,060,000	2,685,000
Other crops					
Orchard	Ton	4,645	145,396	30,659	181,000
Sugar beets	Ton	50,000	775,000	0	825,000
Dry beans	Cwt.	0	207,140	87,003	294,143
Truck crops	Cwt.	47,691	286,146	286,146	619,983
Potatoes	Cwt.	32,000	320,000	288,000	640,000

Table 17 - Projected production from nonirrigated land and range, regionally interpreted OBERS level of development, Upper Colorado Region

Crop	Unit	Green River	Upper Main Stem	San Juan-Colorado	Region
		Year 1980			
Forage					
Hay	Ton	33,437	10,613	12,950	57,000
Cropland pasture	AUM	29,601	6,026	30,373	66,000
Range	AUM	3,079,510	1,227,660	2,167,830	6,475,000
Feed grains					
Oats	Bu.	253,239	56,546	24,215	334,000
Barley	Bu.	337,287	43,511	46,202	427,000
Other crops					
Wheat	Bu.	1,239,981	179,511	1,967,508	3,387,000
Dry beans	Cwt.	0	17,361	625,639	643,000
		Year 2000			
Forage					
Hay	Ton	35,196	11,172	13,632	60,000
Cropland pasture	AUM	33,638	6,847	34,515	75,000
Range	AUM	3,543,696	1,412,709	2,494,595	7,451,000
Feed grains					
Oats	Bu.	282,050	62,980	26,970	372,000
Barley	Bu.	373,623	48,199	51,178	473,000
Other crops					
Wheat	Bu.	1,384,224	200,393	2,196,383	3,781,000
Dry beans	Cwt.	0	18,576	669,424	688,000
		Year 2020			
Forage					
Hay	Ton	37,542	11,917	14,541	64,000
Cropland pasture	AUM	37,586	7,651	38,567	83,804
Range	AUM	3,645,474	1,453,284	2,566,242	7,665,000
Feed grains					
Oats	Bu.	310,104	69,244	29,652	409,000
Barley	Bu.	409,168	52,784	56,048	518,000
Other crops					
Wheat	Bu.	1,528,101	221,222	2,424,677	4,174,000
Dry beans	Cwt.	0	19,764	712,236	732,000

Eighty percent of the 1,621,500 acres of presently irrigated land has a potential for increased crop yield. Increased yields can be obtained with adequate water supply, improved cultural practices, and increased fertilizer use. There is also a need for water control structures, land leveling and smoothing, drainage, and rehabilitation of distribution systems.

Additional storage, new and enlarged diversion systems, and measures to improve irrigation systems are needed to provide water for short water supply lands. Ground water may provide a small amount of supplemental water. Both quantity and seasonal distribution of the irrigation water affect the adequacy of the supply.

Irrigated cropland approximating 500 to 1,000 acres is changed to utilities, transportation, urban, and industrial uses annually. Often this change in use affects the more productive, deep, well-drained soils on nearly level slopes. Replacement in terms of aggregate production often requires an even larger acreage. The tabulation as follows summarizes the conversion of irrigated cropland to other uses during the period 1965 to 2020.

	Loss of irrigated cropland, 1965 to 2020 (acres)					
	To urbanization	Interstate highway right-of-way	Reservoir inundation	Abandonment of present irrigated	To fish and wildlife	Total
Green River	11,500	0	3,400	13,200	1,800	29,900
Upper Main Stem	15,500	2,500	6,000	8,500	0	32,500
San Juan-Colorado	15,200	0	0	9,200	0	24,400
Region total	42,200	2,500	9,400	30,900	1,800	86,800

Dry Cropland

Approximately 400,000 acres of dry cropland are affected by moderate and locally severe erosion. Reduction of erosion on dry cropland requires contour or cross-slope tillage, establishment of grass waterways, fall chiseling in areas of deep snow accumulation, and limited tillage using stubble mulch methods. Rotation of cropland between annuals and grass hay or pasture improves the soil structure and reduces erosion.

About 10 percent of the dry cropland or 60,000 acres should be shifted to sod crops, such as rotation hay or pasture, in order to reduce erosion and lower production costs. This land is in small tracts scattered through large blocks of dryfarm land. Most of these lands have shallow soils and steep slopes but some are gravelly and stony or severely eroded.

Low crop yields are characteristic of approximately 80 percent of the dry cropland acreage. Increases in crop yield can be obtained by use of improved varieties, disease control, and adoption of improved cultural practices to conserve soil moisture and maintain fertility.

Nearly all dry croplands receive low and erratic precipitation during the growing season. Improved land management to conserve moisture is desirable. A change of land use to either range and pasture lands or to irrigated cropland is one solution. Not all dry cropland can be irrigated due to rolling topography and/or steep slopes. An estimated 95,000 acres of dry cropland will be irrigated by developing a water supply and distribution system. About 3,000 acres would go to urban and other uses and 2,000 acres would be inundated by reservoirs.

Livestock Grazing

The primary objective of plans for livestock forage production is to meet the demands for output on a sustained yield basis. Grazing use during the early development period was almost wholly oriented to the care and management of the livestock with little or no study of the characteristics of the vegetation and soils nor the effect of grazing on them. Years of overuse have had severe and, in some cases, irreversible effects upon the productive capacity of the land. Soils have been exposed to erosion, native perennial forage plants have been reduced or even eliminated, noxious and unpalatable native and exotic plants have increased, and other deleterious consequences of unregulated use have taken place. Correcting the results of this sequence of events is the central problem to be overcome in order to meet the projected needs for forage production and also to meet watershed management objectives.

In the base year 5.8 million acres of unsuitable land were being grazed. The forage removed from these acres plus overuse of the suitable grazing lands totaled about 430,600 animal unit months or about 6.8 percent of the total amount grazed. Eliminating the abuse and placing all grazing use on a sustained yield basis would eliminate most of the adverse effects connected with grazing use and provide for the required production of AUM's as shown in Table 17.

Conversions of grazing land to meet other uses are estimated as follows: to recreation - 208,000 acres; inundated by reservoirs - 80,000 acres, to irrigated - 492,000 acres; to minerals - 130,000 acres; to flood control - 6,000 acres; to single-purpose fish and wildlife - 65,000 acres; and to urban, industrial, transportation, and utilities - 244,000 acres.

Timber Production

The forest situation can, and undoubtedly will, change greatly during the next 50 years. It is quite possible that changes over this period

will be greater in the Upper Colorado than in any other major region in the country. So far the region has been very lightly harvested for timber production, even in comparison with the Mountain States area as a whole, which in turn is far below the United States' average.

In projecting future timber supply and demand, assumptions as to the area of forest land that would be suitable and available for commercial use are some of the most critical and difficult of all the assumptions that must be made. One certain assumption is that by 2020 forest area will be less than it is now. Agriculture, urban development, construction of roads, powerlines, and reservoirs are all expected to result in some of the present commercial and noncommercial forest area going to nonforest. These outright reductions in forest area would probably have less effect on the future timber supply than changes in classification within the forest area. Since in the case of most of the public lands the commercial forest area is the base for calculating allowable cut, any reclassification of commercial area to noncommercial will tend to reduce timber inventory, yields, and employment. It is premature to make assumptions as to the magnitude of changes resulting from future reexaminations. But it is quite possible that such changes will result in considerably less commercial forest area than is shown by projections in this report. The depressing effect on projected timber yields and employment could be offset by much more intensive management on the remaining lands. Projections that have been made of forest area show a reduction of 225,000 acres of commercial forest from 9.419 to 9.194 million acres or 2.4 percent.

The total output to meet adjusted demands for timber products is projected to rise from 47.8 million cubic feet in 1965 to 340 million (sustained yield potential) in 2020--about seven times the 1965 output. Timber production is shown below.

Subregion	1980	2000	2020
	(thousands of cubic feet)		
Green River	50,200	84,400	99,700
Upper Main Stem	72,500	125,300	152,900
San Juan-Colorado	47,700	76,100	87,400
Region total	170,400	285,800	340,000

Urban, Industrial, Transportation, and Utilities

There would be a need for about 330,000 acres of additional land for these uses by the year 2020.

Much of the urban and industrial area of the region is troubled with high ground water and salinity. It is estimated that 47,000 acres of this land use are presently affected.

Erosion is a problem on an estimated 286,000 acres of the present 929,000 acres and causes $502,000 average annual damage. Flood and sediment damage occurs on 12,000 acres in upstream watersheds, causing $223,000 average annual damages. Additional estimated average annual flood damages to main-stem urban areas total $969,000. Future urban development should be planned for areas outside flood plains where feasible and adequate water supplies, reasonable topography, and good soil conditions occur or can be reasonably provided.

Watershed management

Watershed management seeks to maintain and improve the productivity and environmental stability of the land base. In order to produce the goods and services required in an expanding economy, the demands upon the resource base must be met by wise management and implementation of measures designed to protect and conserve the resource at the new level. This is the task of watershed management.

Conservation of the environment and wise use of the resources require restoration measures including revegetation. In addition to providing protection, additional forage is available for livestock and wildlife use, water quality is enhanced for a host of uses, and environmental and esthetic quality are improved for recreation and other uses. Thus, watershed management requires close coordination with all resource production programs.

Erosion, flood and sediment, and fire are the most significant problems in terms of damage to upstream watersheds. Damages resulting from upstream watershed problems are those that occur in tributary areas of 250,000 acres (400 square miles) or less. These upstream damages total $8.7 million annually. Economic losses are attributed to: erosion - $6.7 million, flood and sediment - $1.4 million, and fire - $0.6 million. Table 18 summarizes problems and damages for the region. The present sediment yield rates indicated on the map following page 52 delineate the watershed sediment problem areas.

Flood control

Land areas in the flood plains of the principal rivers and streams that need flood protection include 100,000 acres in the Green River subregion, 50,000 acres in the Upper Main Stem subregion, and 70,000 acres in the San Juan-Colorado subregion for a regional total of about 220,000 acres. There are many thousands of acres in the upstream watershed in each subregion that need land treatment and water control measures for the control of flood runoff and sediment. Nonstructural flood plain management should be implemented in urban areas and other developed areas to reduce flood damages by regulating use of flood prone lands. Needs expressed in terms of estimated future average flood damages, if no

additional flood protection programs are instituted after 1965, are indicated in the following tabulation.

Subregion	Average annual flood damages in $1,000			
	1965	1980	2000	2020
Green River	998	1,469	2,306	3,558
Upper Main Stem	1,076	1,591	2,512	3,983
San Juan-Colorado	718	1,131	1,956	3,010
Total	2,792[1]	4,191	6,774	10,551

1/ Includes $1.4 million upstream flood and sediment damages.

Irrigation and drainage

Increased irrigation is needed to meet the growing demands for agricultural products.

Field crop projections have been modified to utilize available resources to produce livestock and livestock products to meet needs generated by OBERS as published (Table 15). The irrigated acreages required to meet the projected production of these agricultural products are shown in Table 19. These acreages reflect the projected increases in crop yield shown on Table 34.

Additional water will be required for potentially irrigable lands as well as a supplemental supply for the existing irrigated areas which are short of a full water supply (Table 20) to meet the future demands for food and fiber. Water requirements per acre for potentially irrigable lands are expected to be essentially the same as those for presently irrigated lands. Current water requirements reflect the wide variation in climatic conditions, soil and topographic conditions, irrigation practices, and the mix of crops grown. Since many of the potentially irrigable lands are interspersed and adjacent to irrigated land, climatic and physical conditions will be similar. Irrigated lands would continue to be used principally for production of crops which support the livestock industry. Although improved technology in use of water for irrigated agriculture is taking place, the effect on the water actually consumed by the crops is expected to be small.

Estimates of irrigation requirements based on the current cropping pattern and a full water supply are shown in the tabulation on page 52. Irrigation requirements are the lowest in the higher areas of the subregions where the growing season is shorter and the precipitation greater as compared with lands at lower elevations.

Table 18 - Average annual damages resulting from upstream watershed problems, 1965 conditions, Upper Colorado Region

Problem	Land category	Area affected (1,000 acres)	Average annual damages (thousands of dollars)								
			Land productivity	Land	Crops and livestock	Improvements, inventory and equipment	Public facilities	Depletion of reservoir capacity	Fire suppression costs and related emergency measures	Other	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Erosion	Forest and range	29,119	4,393	359			943				5,695
	Cultivated and pasture	1,075	154	327			41				522
	Urban	183		435			45				480
	Other	103	4	11			7				22
	Subtotal	30,480	4,551	1,132			1,036				6,719
Flood and sediment	Forest and range	69				45	36				81
	Cultivated and pasture	348			701	76	58				835
	Urban	12				32	191				223
	Other					78	1	114		74	267
	Subtotal	429			701	231	286	114		74	1/1,406
Fire	Forest and range	27			52		5		530		587
	Region total		4,551	1,132	753	231	1,327	114	530	74	8,712
Subregions	Green		2,285	380	337	92	407	49	273	22	3,845
	Upper Main Stem		717	426	239	77	546	30	203	30	2,268
	San Juan-Colorado		1,549	326	177	62	374	35	54	22	2,599

1/ This figure is included in the total average annual flood damages on page 48.

Table 19 - Projected acreage of irrigated crops, regionally interpreted OBERS level of development, Upper Colorado Region (Unit--acres)

Crop	Hydrologic subregion: Green River	Upper Main Stem	San Juan-Colorado	Region
Year 1980				
Hay				
Alfalfa	109,745	129,091	79,509	318,345
Other hay				
Improved	50,794	39,847	11,359	102,000
Native	163,304	81,802	11,394	256,500
Subtotal	323,843	250,740	102,262	676,845
Pasture				
Rotation (cropland)	148,990	110,357	76,017	335,364
Permanent (noncropland)	115,764	88,318	41,755	245,837
Other (noncropland)	62,800	54,564	45,427	162,791
Subtotal	327,554	253,239	163,199	743,992
Corn silage	8,589	20,352	12,554	41,495
Feed grains				
Oats	15,943	21,510	8,787	46,240
Barley (exclude Moravian)	11,783	5,321	7,655	24,759
Corn	681	16,076	4,207	20,964
Subtotal	28,407	42,907	20,649	91,963
Other grains				
Barley (Moravian)		23,150	2,727	25,909
Wheat	18,526	3,499	18,651	40,676
Subtotal	18,526	26,649	21,378	66,553
Other crops				
Orchard	500	14,700	3,100	18,300
Sugar beets	1,841	16,209		18,050
Dry beans		8,573	1,532	10,105
Truck crops	300	1,800	1,800	3,900
Potatoes	100	927	754	1,781
Subtotal	2,741	42,209	7,186	52,136
Idle land	51,515	34,855	37,890	124,260
Total	757,478	670,981	365,118	1,793,57[illegible]
Rounded	757,500	671,000	365,100	1,793,600
Year 2000				
Hay				
Alfalfa	112,473	131,346	101,254	345,073
Other hay				
Improved	56,519	34,975	10,506	102,000
Native	163,310	83,805	11,385	258,500
Subtotal	332,302	250,126	123,145	705,573
Pasture				
Rotation (cropland)	178,579	138,966	121,290	438,835
Permanent (noncropland)	115,179	87,409	41,427	244,015
Other (noncropland)	62,400	53,982	45,064	161,446
Subtotal	356,158	280,357	207,781	844,296
Corn silage	11,659	22,528	14,819	49,006
Feed grains				
Oats	13,150	15,616	6,274	35,040
Barley (exclude Moravian)	11,567	8,719	11,979	32,265
Corn	569	16,779	5,610	22,958
Subtotal	25,286	41,114	23,863	90,263
Other grains				
Barley (Moravian)		34,091	6,364	40,455
Wheat	17,391	3,973	17,472	38,836
Subtotal	17,391	38,064	23,836	79,291
Other crops				
Orchard	500	14,700	3,100	18,300
Sugar beets	1,798	22,773		24,571
Dry beans		9,640	2,758	12,398
Truck crops	300	1,800	1,800	3,900
Potatoes	100	964	526	1,590
Subtotal	2,698	49,877	8,184	61,0[illegible]
Idle land	50,909	34,927	38,944	124,780
Total	794,397	716,987	442,818	1,954,20[illegible]
Rounded	794,400	717,000	442,800	1,954,200
Year 2020				
Hay				
Alfalfa	111,200	133,600	127,000	371,800
Other hay				
Improved	60,245	32,104	9,651	102,000
Native	163,316	83,807	11,377	258,500
Subtotal	334,761	249,511	148,028	732,300
Pasture				
Rotation (cropland)	214,161	167,568	166,471	548,200
Permanent (noncropland)	114,600	86,500	41,100	242,200
Other (noncropland)	62,000	53,400	44,700	160,100
Subtotal	390,761	307,468	252,271	950,500
Corn silage	14,596	25,022	16,682	56,300
Feed grains				
Oats	7,880	8,537	3,283	19,700
Barley (exclude Moravian)	11,628	12,093	16,279	40,000
Corn	719	18,692	7,189	26,600
Subtotal	20,227	39,322	26,751	86,300
Other grains				
Barley (Moravian)		45,000	10,000	55,000
Wheat	20,000	5,000	20,000	45,000
Subtotal	20,000	50,000	30,000	100,000
Other crops				
Orchard	500	14,700	3,100	18,300
Sugar beets	2,000	31,000		33,000
Dry beans		10,357	4,143	14,500
Truck crops	300	1,800	1,800	3,900
Potatoes	100	1,000	900	2,000
Subtotal	2,900	58,857	9,943	71,700
Idle land	50,000	35,000	40,000	125,000
Total	833,245	765,180	523,675	2,122,100
Rounded	833,300	765,200	523,700	2,122,100

Table 20 - Projected on-site water depletions by irrigated land (new and supplemental), incidental use, and irrigation reservoir evaporation, regionally interpreted OBERS level of development, Upper Colorado Region

Hydrologic subregion and state	1980 Irrigated land (1,000 acres) Total	1980 Irrigated land (1,000 acres) Supplemental 1/	1980 Water depletions (1,000 acre-feet)	2000 Irrigated land (1,000 acres) Total	2000 Irrigated land (1,000 acres) Supplemental 1/	2000 Water depletions (1,000 acre-feet)	2020 Irrigated land (1,000 acres) Total	2020 Irrigated land (1,000 acres) Supplemental 1/	2020 Water depletions (1,000 acre-feet)
Green River									
Colorado	128.7	5.9	132.0	130.3	13.1	139.0	134.9	19.1	147.0
Utah	287.3	102.6	518.0	284.6	102.6	516.0	305.8	102.6	572.0
Wyoming	341.5	59.0	334.0	379.5	85.0	407.0	392.5	95.0	428.0
Subtotal	757.5	167.5	984.0	794.4	200.7	1,062.0	833.2	216.7	1,147.0
Upper Main Stem									
Colorado	662.8	59.2	1,064.0	709.4	99.3	1,153.0	757.2	126.5	1,216.0
Utah	8.2		14.0	7.6		13.0	8.0	2.0	17.0
Subtotal	671.0	59.2	1,078.0	717.0	99.3	1,166.0	765.2	128.5	1,233.0
San Juan-Colorado									
Arizona	10.0		7.0	9.4		8.0	9.4		9.0
Colorado	211.7	48.8	283.0	247.8	53.8	341.0	259.8	55.8	360.0
New Mexico	104.2	5.5	245.0	139.2	5.5	329.0	174.2	5.5	411.0
Utah	39.2		56.0	46.4	7.0	76.0	80.3	14.6	134.0
Subtotal	365.1	54.3	591.0	442.8	66.3	754.0	523.7	75.9	914.0
Region									
Arizona	10.0		7.0	9.4		8.0	9.4		9.0
Colorado	1,003.2	113.9	1,479.0	1,087.5	166.2	1,633.0	1,151.9	201.4	1,723.0
New Mexico	104.2	5.5	245.0	139.2	5.5	329.0	174.2	5.5	411.0
Utah	334.7	102.6	588.0	338.6	109.6	605.0	394.1	119.2	723.0
Wyoming	341.5	59.0	334.0	379.5	85.0	407.0	392.5	95.0	428.0
Total	1,793.6	281.0	2,653.0	1,954.2	366.3	2,982.0	2,122.1	421.1	3,294.0

1/ Supplemental acreage included in total.

Summary of irrigation water requirements for potentially irrigable lands--Upper Colorado Region (consumptive use minus effective precipitation)
(Unit--acre-feet per acre)

Hydrologic subregion	Composite crop irrigation requirement
Green River	0.90-1.61
Upper Main Stem	1.05-1.97
San Juan-Colorado	1.04-1.97

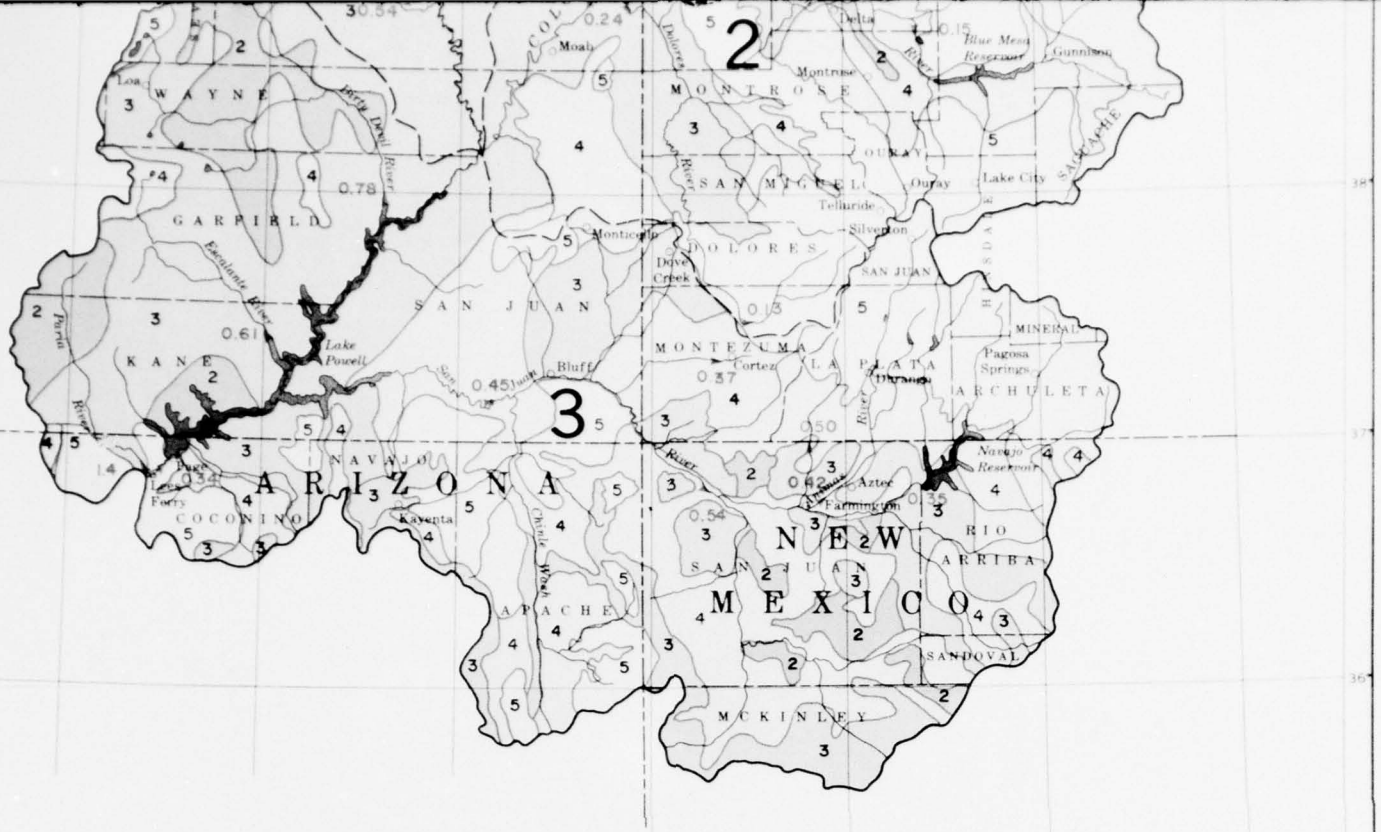
Irrigation practices and drainage requirements on newly developed irrigable lands will be comparable to those now existing on closely associated irrigated lands in the region. It will be essential not only to provide drainage for newly developed areas, but also to maintain production on presently irrigated lands by providing canal lining and some additional drainage works.

In addition to drainage already provided for presently irrigated lands, on-farm drainage is needed on 436,900 acres of presently irrigated lands in the region, requiring 4,093 miles of open ditches and tile drains, as shown in the following tabulation.

Presently irrigated acres needing drainage
Upper Colorado Region

Hydrologic subregion and state	Drainage (tile and ditches) (miles)	Presently irrigated lands needing drainage (1,000 acres)
Green River		
Colorado	215	23.0
Wyoming	584	62.3
Utah	680	72.6
Subtotal	1,479	157.9
Upper Main Stem		
Colorado	1,017	108.5
Utah	23	2.5
Subtotal	1,040	111.0
San Juan-Colorado		
Arizona	28	3.0
Colorado	1,378	147.0
New Mexico	140	15.0
Utah	28	3.0
Subtotal	1,574	168.0
Region total	4,093	436.9


GREAT BASIN
UPPER COLORADO
LOWER COLORADO
PACIFIC OCEAN
WYOMING
SUBLETTE
LINCOLN
SWEETWATER
Kemmerer
Fontenelle Reservoir
Green River
Rock Springs
UINTA
Flaming Gorge Reservoir
CARBON
SUMMIT
DAGGETT
MOFFAT
ROUTT
Craig
Steamboat Springs
Vernal
Roosevelt
DUCHESNE
Duchesne
UINTAH
WASATCH
Meeker
RIO BLANCO
GRAND
Hot Sulphur Springs
GARFIELD
Glenwood Springs
Eagle
Breckenridge
PITKIN
Aspen
Price
CARBON
UTAH
COLORADO
Castle Dale
Green River
EMERY
GRAND
Grand Junction
MESA
DELTA
GUNNISON
Delta
Blue Mesa Reservoir
Gunnison
Moab
Montrose
MONTROSE
OURAY
Ouray
Lake City
WAYNE
GARFIELD
SAN MIGUEL
Telluride
Monticello
Silverton
DOLORES
Dove Creek
SAN JUAN
1
2



YIELD CLASS	YIELD RATE 1/ Ac.Ft./Sq.Mi./Yr.	TOTAL AREA Sq Miles
1	> 3.0	2/
2	1.0 - 3.0	8,000
3	0.5 - 1.0	33,000
4	0.2 - 0.5	42,000
5	< 0.2	31,000

1/ Do not use these rates to estimate accumulative volume yields. Instead use stream gage rates.

2/ Too small to delineate

SUBREGIONS
1 Green River
2 Upper Main Stem
3 San Juan - Colorado

N

PRESENT SEDIMENT YIELD RATES

25 0 25 50 75 100 125 150 MILES

1969

Prepared by the Land Use and Management Work Group of the Upper Colorado Region

UPPER COLORADO REGION
COMPREHENSIVE FRAMEWORK STUDY

GPO 855 - 144

Approximately 1,060 miles of project-type drains are needed also on the 436,900 acres of presently irrigated drainage-deficient lands. These types of drains are installed as project developments which are not a direct cost to individual landowners.

An estimated 176,300 acres of the new lands projected to be developed by 2020 will need on-farm drainage, as listed on the following tabulation.

Projected acreage of new land development needing on-farm drainage[1/]
(1,000 acres)

Hydrologic subregion and state	1980	2000	2020	Total
Green River				
Colorado	4.7	1.6	1.9	8.2
Utah	2.5	.3	4.2	7.0
Wyoming	10.5	12.7	7.0	30.2
Subtotal	17.7	14.6	13.1	45.4
Upper Main Stem				
Colorado	18.1	19.2	16.1	53.4
Utah	0	0	.3	.3
Subtotal	18.1	19.2	16.4	53.7
San Juan-Colorado				
Arizona	0	0	0	0
Colorado	9.0	12.2	3.9	25.1
New Mexico	16.0	11.4	11.7	39.1
Utah	0	5.6	7.4	13.0
Subtotal	25.0	29.2	23.0	77.2
Region total	60.8	63.0	52.5	176.3

1/ Represents approximately 30 percent of projected new land acreage to be developed for irrigation.

An estimated 1,651 miles of drains will be needed to provide on-farm drainage for the 176,300 acres of new land developed by 2020. An additional 420 miles of project-type drains are also needed for the 176,300 acres of new lands.

Municipal and industrial water

There is an increasing need for domestic water to satisfy the population growth of the region. Also, an increase in per capita use is

anticipated, particularly by the rural residents and its Indian population. Manufacturing needs for water are estimated to increase in total; however, the projected growth is accompanied by a more efficient use of the water supply. The water needs for governmental and commercial uses are expected to increase. Table 21 indicates the total municipal and industrial needs by states and subregions for the time periods ending 1980, 2000, and 2020. Table 22 indicates needs in terms of withdrawals and depletions for various categories of municipal and industrial uses.

Recreation

The region contains resources that provide for unique recreation opportunities in a setting of a quality environment. Mostly they provide a base for extensive rather than intensive use and are available for other uses that may or may not be compatible with recreation. This is evidenced by the approximately 49 million acres that were inventoried as suitable for recreation use, of which all but about 71,000 acres are under multiple uses. These are essentially public lands under administration of the Forest Service, National Park Service, and Bureau of Land Management. Another large sector involves Indian reservation lands. Future needs for recreation in general require expansion of facilities within the existing areas. Nonresidents now account for about 97 percent of the present use, while residents of the region account for the remaining 3 percent. It is anticipated that future needs will involve approximately this same proportionate use. This disproportionate use by nonresidents may warrant consideration on how many needs will or should be met. The figure following page 56 shows recreation demand by subregion and time frames.

Overall needs for primary-purpose developed recreation land, undeveloped recreation land, and water surface acres are summarized in Table 23 and shown graphically on the figures following page 58. Due to the concentration of large amounts of water in a few locations, there are areas of local water need even though there is generally an overall surplus of water acreage.

Small bodies of water of up to about 500 surface acres are needed. These smaller lakes usually offer far more benefits per acre, generally are better suited to meet local needs, and are especially necessary near the larger urban areas.

The need for protection and preservation of outstanding areas and the maintenance of a quality environment overshadows that of providing additional land and water areas for recreation. It may also overshadow the need for other types of development and resource use.

The continuing increase in population, more leisure time, and disposable income coupled with better transportation facilities and technological development in recreation equipment are some of the major

Table 21 - Projected municipal and industrial water withdrawals and depletions, subregions and states, Upper Colorado Region (acre-feet per year)

Subregion and state	1980		2000		2020	
	Withdrawal	Depletion	Withdrawal	Depletion	Withdrawal	Depletion
Green River						
Colorado	7,600	2,600	11,900	4,100	16,700	6,200
Utah	14,200	4,800	20,100	6,900	29,800	11,000
Wyoming	12,800	4,300	17,200	5,900	25,000	9,200
Subtotal	34,600	11,700	49,200	16,900	71,500	26,400
Upper Main Stem						
Colorado	46,700	15,200	70,100	23,200	104,600	37,200
Utah	3,000	1,000	5,300	1,700	9,100	3,200
Subtotal	49,700	16,200	75,400	24,900	113,700	40,400
San Juan-Colorado						
Arizona	1/9,000	2,900	1/14,000	4,800	1/19,000	7,200
Colorado	12,200	4,300	19,700	7,000	33,600	12,600
New Mexico	16,700	5,900	29,500	10,600	46,300	17,300
Utah	5,600	2,000	9,700	3,500	16,600	6,200
Subtotal	43,500	15,100	72,900	25,900	115,500	43,300
Region						
Arizona	1/9,000	2,900	1/14,000	4,800	1/19,000	7,200
Colorado	66,500	22,100	101,700	34,300	154,900	56,000
New Mexico	16,700	5,900	29,500	10,600	46,300	17,300
Utah	22,800	7,800	35,100	12,100	55,500	20,400
Wyoming	12,800	4,300	17,200	5,900	25,000	9,200
Total	127,800	43,000	197,500	67,700	300,700	110,100

1/ Estimated from withdrawal-depletion ratio developed for San Juan-Colorado economic subregion.

Table 22 - Projected municipal and industrial water withdrawals and depletions, Upper Colorado Region[1/]

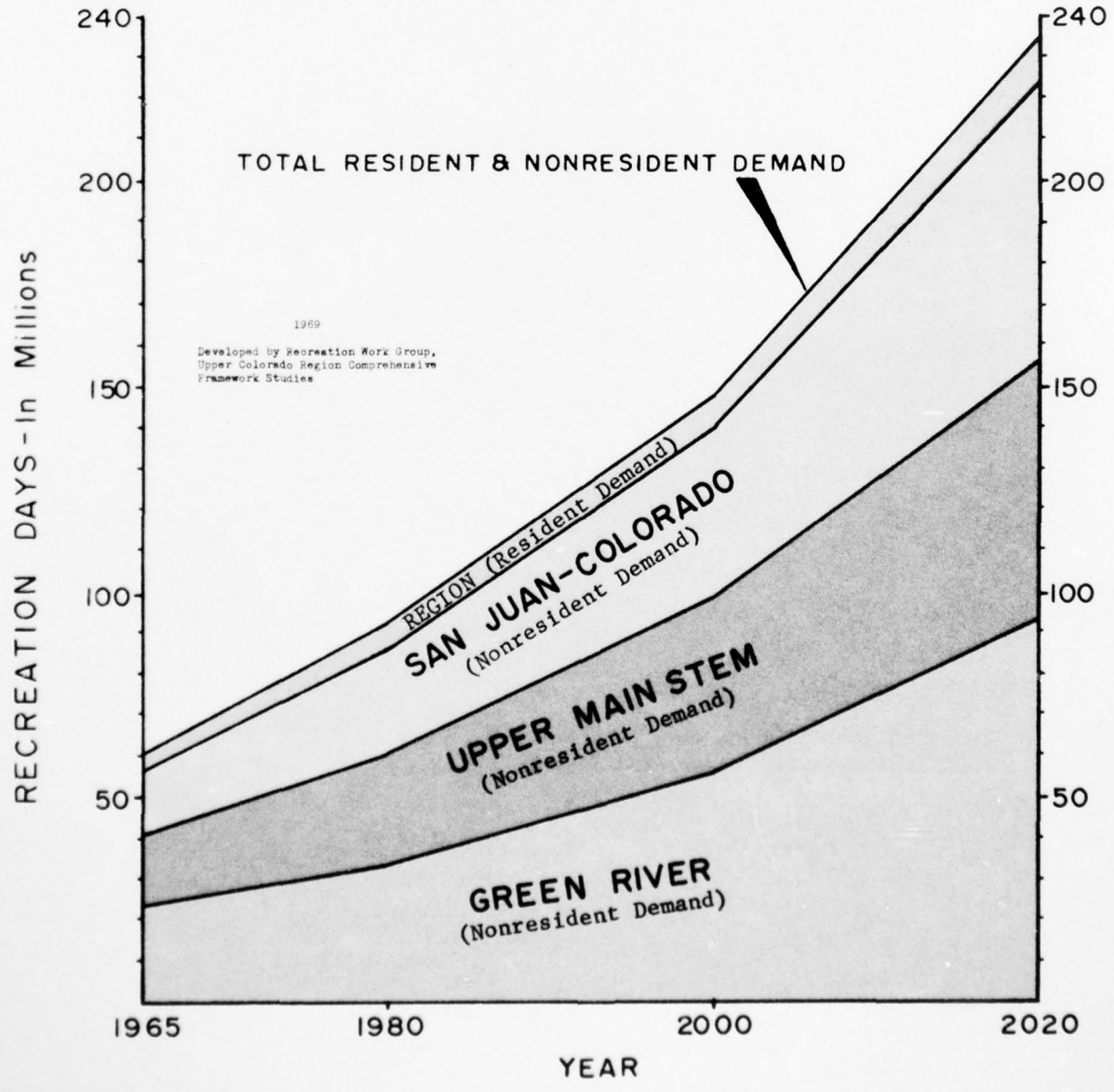
	Water in acre-feet per year			
	1965	1980	2000	2020
Withdrawal				
Domestic	50,900	54,800	66,300	81,100
Manufacturing	12,200	20,300	36,200	62,400
Governmental	10,700	16,400	27,900	43,700
Commercial	15,700	27,300	53,100	94,400
Total	89,500	118,800	183,500	281,600
Depletion				
Domestic	17,300	23,300	28,800	35,900
Manufacturing	1,900	3,400	6,700	12,700
Governmental	1,100	2,000	4,200	8,800
Commercial	6,400	11,400	23,200	45,500
Total	26,700	40,100	62,900	102,900

1/ Based on economic boundaries, Arizona uses of 2,900 acre-feet in 1980, 4,800 in 2000, and 7,200 in 2020 not included.

UPPER COLORADO REGION

RECREATION DEMAND

RECREATION DAYS – Including Hunting & Fishing



GPO 831-456

Table 23 - Recreation land and water surface needs, regionally interpreted OBERS level of development, Upper Colorado Region
(Unit--1,000 acres)

Year		Classes[1] I	II	III	IV	V	VI	
1965	Developed land	0.5	4.7	3.2	1.1	0.5	0.5	10.5
	Undeveloped land[2]	3.1	28.1	125.0				156.2
	Water[3]							--
1980	Developed land	3.4	31.0	20.7	6.9	3.4	3.4	68.8
	Undeveloped land	31.7	285.4	1,268.3				1,585.4
	Water[3]							--
2000	Developed land	10.1	90.6	60.4	20.1	10.0	10.1	201.3
	Undeveloped land	109.2	982.5	4,366.7				5,458.4
	Water[3]							--
2020	Developed land	21.7	195.6	130.5	43.5	21.7	21.7	434.7
	Undeveloped land	248.2	2,233.1	9,925.2				12,406.5
	Water[3]							332.9

[1] Classes:
I - High-density recreation areas.
II - General recreation areas.
III - Natural environment areas.
IV - Outstanding natural areas.
V - Primitive areas (wilderness).
VI - Historical and cultural sites.

[2] Needs calculated only for Classes I, II, and III.

[3] Water needs in surface acres not assigned by classes.

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UPPER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY. APPENDIX X--ETC(U)
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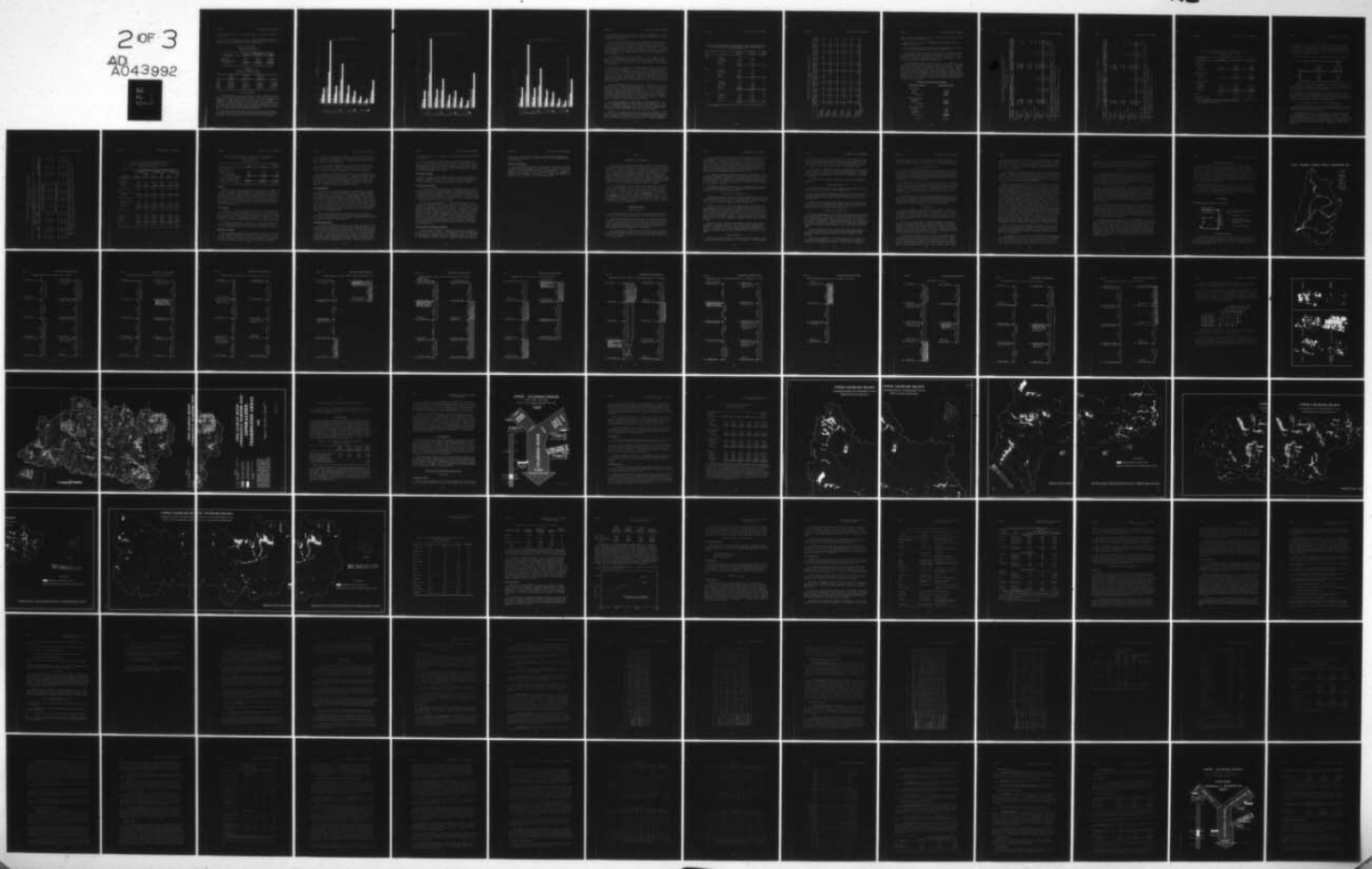


factors that will place an ever-growing demand on recreation resources in the region.

Demand for the various activities is fairly uniform throughout the region regardless of subregion or target year. The greatest exception, however, is winter sports activities, as shown below.

Winter sports demand in
Upper Colorado Region
(1,000 activity days)

Subregion	Target dates		
	1980	2000	2020
Green River	724.8	1,340.0	2,168.2
Upper Main Stem	7,543.1	14,947.4	21,015.7
San Juan-Colorado	481.8	951.4	1,456.9
Total	8,749.7	17,238.8	24,640.8

Summary of
outdoor recreation demand
(thousands of recreation days)

Year	Green River subregion	Upper Main Stem subregion	San Juan-Colorado subregion	Region
1965	22,969.1	15,970.3	16,985.7	55,925.1
1980	34,289.2	25,219.0	25,980.6	85,488.8
2000	55,533.5	42,261.7	42,669.7	140,464.9
2020	92,359.0	63,402.2	69,380.2	225,141.4

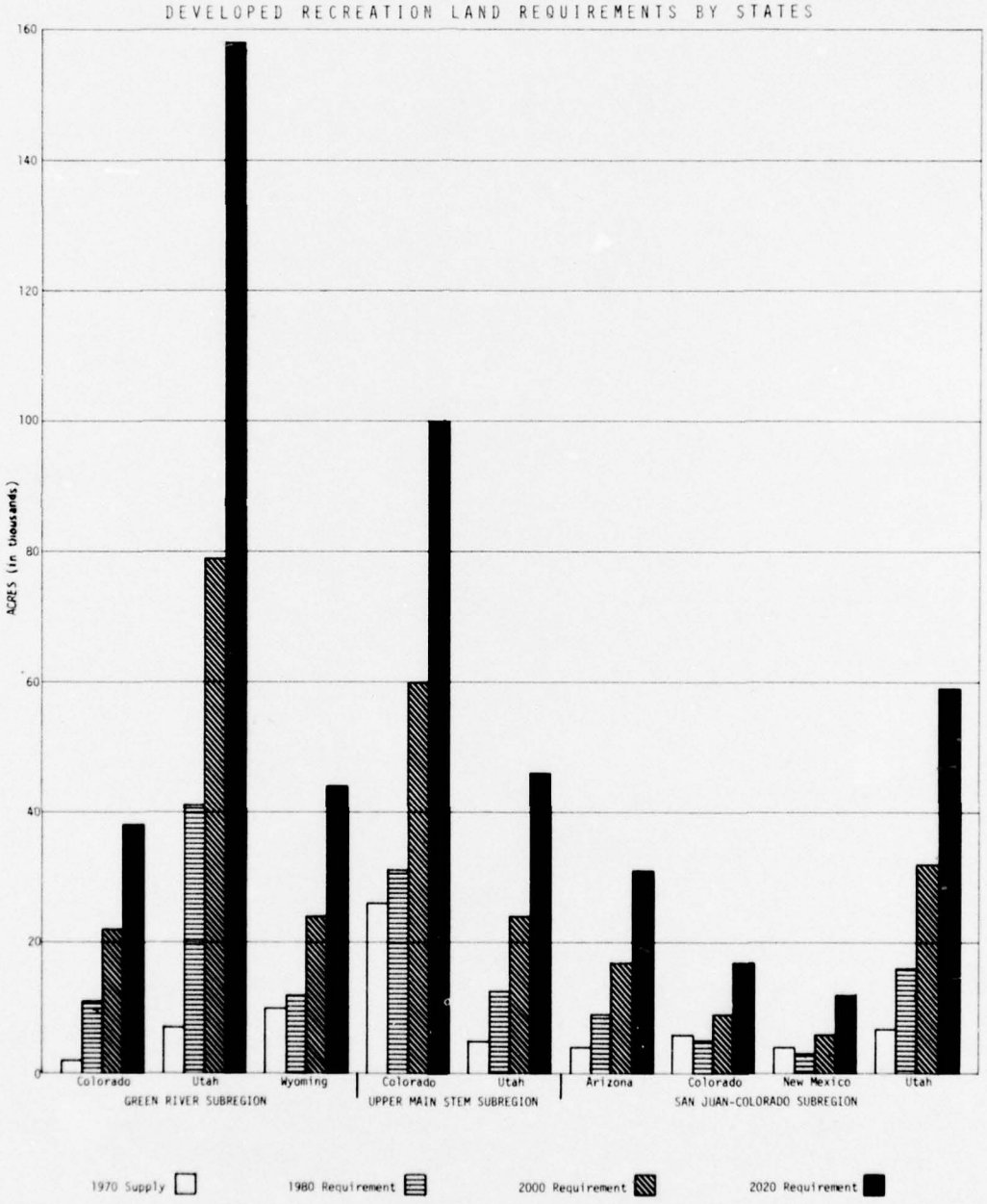
Fish and wildlife

Fish and wildlife needs are described in terms of quality as well as quantities and of national as well as regional objectives. Because of its relatively low human population and low level of resource development in comparison to other areas, the region retains much of its endowment of attractive, unpolluted streams and lakes and a full complement of wildlife in habitats not greatly changed since settlement started over a century ago. For example, some of our largest North American animals--elk, moose, antelope, bighorn sheep, and mule deer--are common.

With such attributes the region can become increasingly unique as other parts of the country become more heavily populated and intensively developed. It would be a place for all citizens to visit and enjoy,

UPPER COLORADO REGION

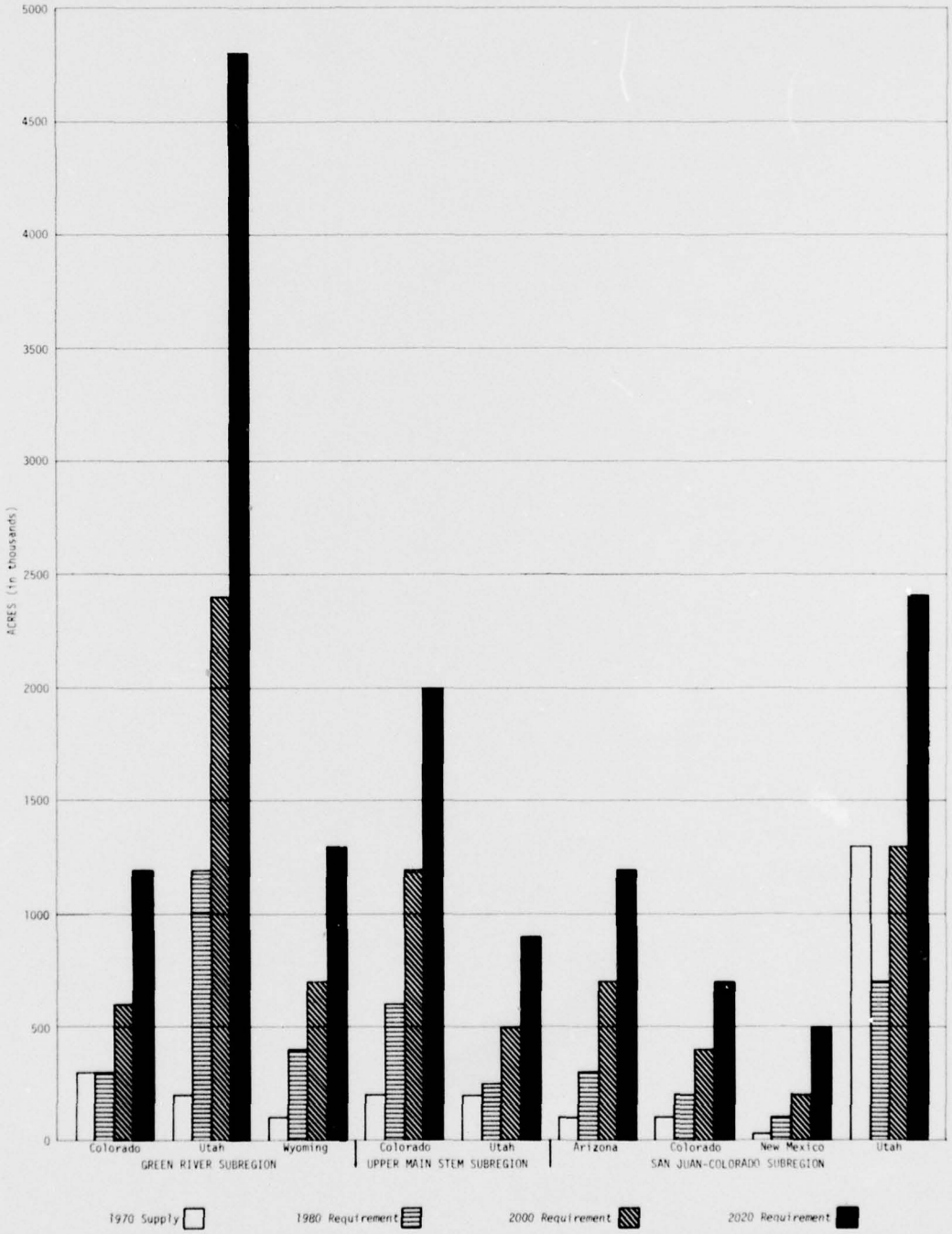
DEVELOPED RECREATION LAND REQUIREMENTS BY STATES



NOTE: To obtain needs, subtract supply from requirements. Where supply exceeds requirements, no overall need exists but local unmet needs may still occur.

UPPER COLORADO REGION

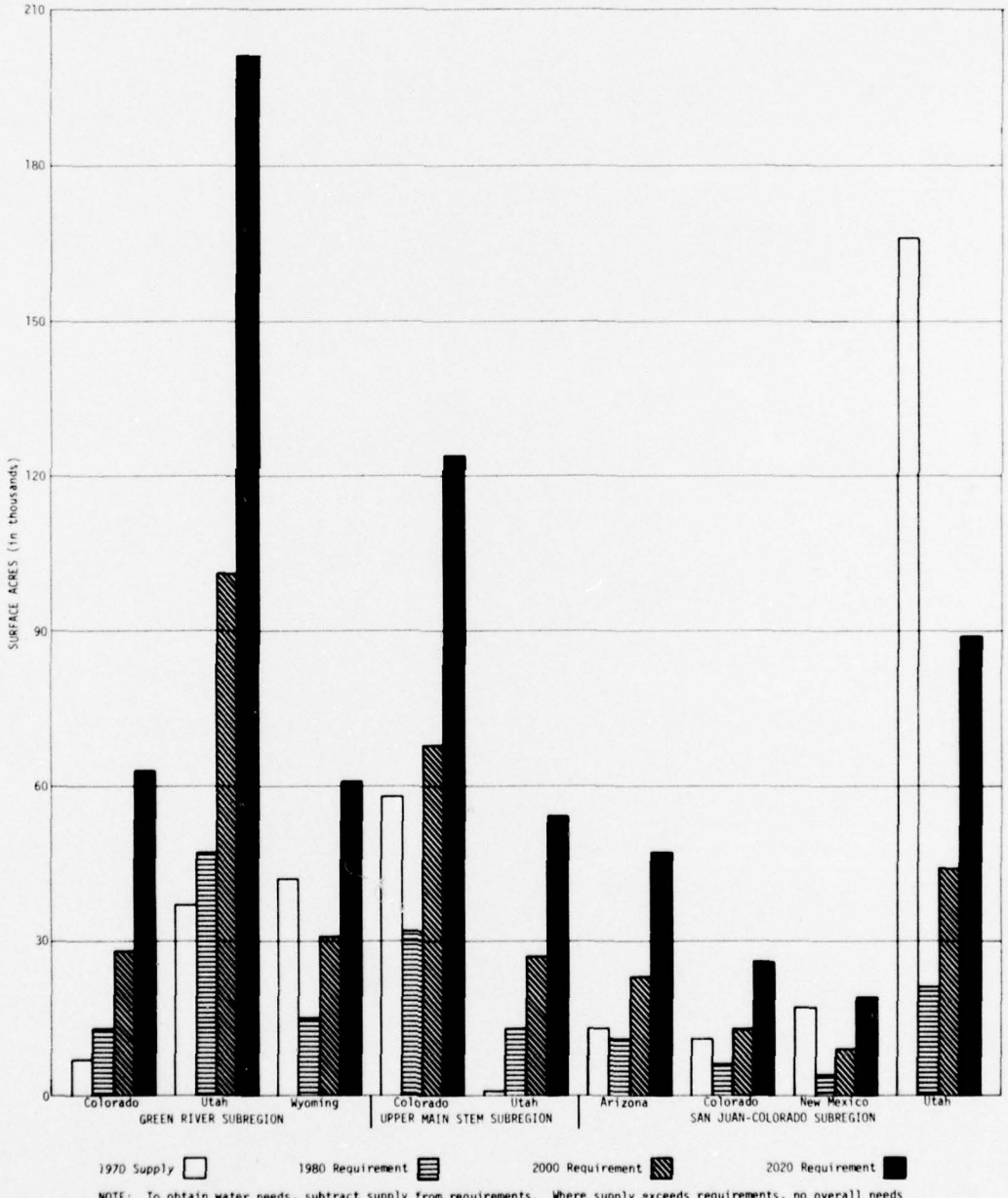
UNDEVELOPED RECREATION LAND REQUIREMENTS BY STATES



NOTE: To obtain needs, subtract supply from requirements. Where supply exceeds requirements, no overall needs exist but local unmet needs may still occur. Supply represents acreage on areas where recreation is the dominant use

UPPER COLORADO REGION

RECREATION WATER REQUIREMENTS BY STATES



NOTE: To obtain water needs, subtract supply from requirements. Where supply exceeds requirements, no overall needs exist but local unmet needs may still occur.

where one might fish in clear waters in uncrowded surroundings, or hunt unusual birds such as the sage grouse, or watch for wildlife in mountains, valleys, and canyon lands.

Projected needs for sport fishing were estimated by comparing projected demand with potential supply. This comparison is summarized in Table 24. For most of the region there would be ample fishing waters through 2020, although there must inevitably be much crowding on the heavily fished areas, with a resultant deterioration in quality. Only in Arizona and New Mexico are substantial shortages of fishing opportunity forecasted because of the projected large increases in the Indian population in those states.

Commercial fisheries are a minor fraction of the economy. Most of them are trout hatcheries or rearing units. If these enterprises are to keep pace with projected population and economic growth, annual production would need to be increased from about 200,000 pounds to an estimated 405,000 pounds.

Future needs for hunting were estimated after recognizing practices and trends in state management. A limited number of permits are allowed for most species of big game, the mule deer being the notable exception. Also the trend is to limit nonresident hunting as the demand for residents grows. It was realized, also, that growing demand for hunting would result in lesser success; i.e., more time will be spent hunting for each animal taken. Demand was calculated within these limitations as shown in Table 25. Without them the theoretical demand would be many times greater than the supply.

Most of the region can be expected to have enough game for its needs through 2020. The exceptions are Arizona and New Mexico, as in the case of future fishing needs, and Wyoming, which also will have a significant shortage of resident game animals throughout much of the study period. In Colorado and Utah game resources and habitat capabilities appear to be adequate, though local shortages undoubtedly will occur. Anticipated shortages, wherever they occur, will develop largely through a combination of increased demand and reduction in habitat. Criteria for identifying the decrease in habitat were land-use changes.

Fur animal trapping may be disregarded as a meaningful need. As in the past, trapping will be done when animals are available and the fur price is adequate, or when species in need of control are taken for that purpose. Fur animal management is not a major effort of wildlife agencies except in the case of the established control programs.

There are, of course, many other needs for fish and wildlife, needs that cannot be conveniently expressed in such terms as man-days of activity. Conservation of all forms of fish and wildlife for the enjoyment of future generations will be of continuing concern. As human populations

Table 24 - Sport fishing - future capabilities and needs, regionally interpreted OBERS level of development, Upper Colorado Region
(1,000 man-days)

Year	State	Habitat capacity	Fishing demand	Unmet demand
1965	Arizona	121	32	
	Colorado	4,806	1,896	
	New Mexico	412	371	
	Utah	3,025	1,040	
	Wyoming	1,590	208	
		9,954	3,547	S
1980	Arizona	146	84	
	Colorado	5,570	2,294	
	New Mexico	613	546	
	Utah	3,462	1,353	
	Wyoming	1,630	245	
		11,421	4,522	S
2000	Arizona	148	202	54
	Colorado	5,807	3,206	
	New Mexico	673	905	232
	Utah	3,502	1,877	
	Wyoming	1,681	312	
		11,811	6,502	286
2020	Arizona	151	275	124
	Colorado	5,882	4,174	
	New Mexico	676	1,266	590
	Utah	3,536	2,541	
	Wyoming	1,714	411	
		11,959	8,667	714

S - Surplus

Table 25 - Sport hunting, future capabilities and needs, regionally interpreted OBERS level of development, Upper Colorado Region
(1,000 man-days)

	1965		1980			2000			2020		
	Habitat capacity	Hunting demand	Habitat capacity	Hunting demand	Unmet demand	Habitat capacity	Hunting demand	Unmet demand	Habitat capacity	Hunting demand	Unmet demand
Arizona											
Big game	5	1	5	15	10	7	31	24	8	43	35
Small game	12	1	12	16	4	12	33	21	12	45	33
Waterfowl	1	#	1	3	2	1	6	5	1	8	7
	18	2	18	34	16	20	70	50	21	96	75
Colorado											
Big game	1,157	692	1,126	717		1,112	876		1,117	1,032	
Small game	168	76	171	89		183	121		194	153	
Waterfowl	25	17	35	19		45	27		46	36	
	1,350	785	1,332	825	S	1,340	1,024	S	1,357	1,221	S
New Mexico											
Big game	59	36	61	52		64	80	16	66	109	43
Small game	56	33	60	50		71	80	9	72	111	39
Waterfowl	11	10	16	16		19	26	7	20	35	15
	126	79	137	118	S	154	186	32	158	255	97
Utah											
Big game	499	193	499	234		502	310		509	406	
Small game	554	72	558	91		562	123		566	163	
Waterfowl	38	7	42	8		43	12		45	16	
	1,091	272	1,099	333	S	1,107	445	S	1,120	585	S
Wyoming											
Big game	92	74	85	85		74	99	25	66	117	51
Small game	87	50	87	58		85	71		85	90	5
Waterfowl	8	6	13	7		13	8		14	10	
	187	130	185	150	S	172	178	25	165	217	56
Region											
Big game	1,812	996	1,776	1,103		1,759	1,389		1,766	1,707	
Small game	877	232	888	304		913	435		929	562	
Waterfowl	83	40	107	53		121	79		126	105	
Total	2,772	1,268	2,771	1,460	S	2,793	1,903	S	2,821	2,374	S

# = Less than 500.
S = Surplus.

grow, there will be enlarging interest in wildlife photography and nature study as well as hunting and fishing.

Water needs for new fishing impoundments and waterfowl areas are summarized in Table 26.

Fishing impoundments and waterfowl areas would require land as well as water. Estimated land requirements appear in Table 27.

For big game conservation, lands are purchased or withdrawn primarily for that purpose. There is a continuing need for winter range for mule deer, elk, and moose--a need that becomes critical as normal ranges are converted to irrigation or altered by other kinds of development. Land needs for big game are summarized in Table 28.

For many wildlife species certain portions of the total habitat are so essential that they are the key to survival of the species. Sagebrush range for sage grouse is a good example of an essential habitat component. Key habitat is required for mule deer, elk, moose, antelope, bighorn sheep, sage grouse, turkey, and for waterfowl. These are habitat areas in which wildlife conservation must be an important objective of land management and in which wildlife must be given adequate consideration when changes in land use are proposed or made. The acreages of key habitat in the several states for all of the above species after subtracting for all overlapping is as follows:

Acreage for key habitat for wildlife

Subregion and state	Thousands of acres
Green River	
Colorado	4,495
Utah	4,628
Wyoming	8,128
Subtotal	17,251
Upper Main Stem	
Colorado	10,003
Utah	1,723
Subtotal	11,726
San Juan-Colorado	
Arizona	1,289
Colorado	2,482
New Mexico	3,424
Utah	5,023
Subtotal	12,218
Total	41,195

Table 26 - Consumptive water needs for fish and wildlife, regionally interpreted OBERS level of development, Upper Colorado Region (acre-feet)

Subregion and state	Fishing impoundments			Waterfowl areas		
	1966-1980 1/	1981-2000	2001-2020	1966-1980 1/	1981-2000	2001-2020
Green River						
Colorado	2,860			10,500		
Utah	950			8,400		
Wyoming	190			18,500		
Subtotal	4,000			37,400	2/	2/
Upper Main Stem						
Colorado	4,455			2,100		
Utah	45					
Subtotal	4,500			2,100	2/	2/
San Juan-Colorado						
Arizona	570	900	1,000	3/2,700	3,800	2,700
Colorado	4,670			11,520		
New Mexico	3,310	3,400	5,100	4/4,730	7,400	11,000
Utah	250			4,650		
Subtotal	8,800	4,300	6,100	23,600	2/	2/
Total	17,300	4,300	6,100	63,100	11,200	13,700
Accumulated total		21,600	27,700		74,300	88,000

1/ Programed for construction and development except as noted.

2/ Additional waterfowl areas will be needed if urban, industrial, or major reservoir development should cause serious inroads on existing key habitat.

3/ Not programed for construction.

4/ Includes 1,600 acre-feet not programed for construction.

Table 27 - Land needs for fishing impoundments and waterfowl area, regionally interpreted OBERS level of development, Upper Colorado Region

Subregion and state	Fishing impoundments (acres)			Waterfowl areas (acres)		
	1966-1980[1]	1981-2000	2001-2020	1966-1980[1]	1981-2000	2001-2020
Green River						
Colorado	1,386			14,800		
Utah	458			3,100		
Wyoming	93			19,030		
Subtotal	1,937			36,930	2/	2/
Upper Main Stem						
Colorado	2,713			906		
Utah	27					
Subtotal	2,740			906	2/	2/
San Juan-Colorado						
Arizona	275	440	550	3/1,000	1,400	1,000
Colorado	2,254			5,000		
New Mexico	1,595	1,760	2,640	4/1,960	2,700	4,000
Utah	122			2,018		
Subtotal	4,246	2,200	3,190	9,978	2/	2/
Total	8,923	2,200	3,190	47,814	4,100	5,000
Accumulated total		11,125	14,313		51,914	56,914

1/ Programed for construction and development except as noted.
2/ Additional waterfowl areas will be needed if urban, industrial, or major reservoir development should cause serious inroads on existing key habitat.
3/ Not programed for construction.
4/ Includes 600 acres not programed for construction.

Table 28 - Projected land needs primarily for big-game conservation, Upper Colorado Region
(Unit--acres)

Subregion and state	1965-1980[1]	1981-2000[2]	2001-2020[2]
Green River			
Colorado		7,000	7,000
Utah	23,000	6,000	6,000
Wyoming		5,000	5,000
Subtotal	23,000	18,000	18,000
Upper Main Stem			
Colorado		11,000	11,000
Utah		3,000	3,000
Subtotal		14,000	14,000
San Juan-Colorado			
Arizona			
Colorado	800	4,000	4,000
New Mexico	13,620	8,000	8,000
Utah		6,000	6,000
Subtotal	14,420	18,000	18,000
Period	37,420	50,000	50,000
Accumulated total		87,420	137,420

1/ Programed for construction and development.
2/ To meet future demand.

Electric power

Estimates of future demands for electrical energy have been made based upon a study of population, customers as related to population, past growth of customer usage (residential, commercial, industrial), known economic development, and other factors. Consideration has also been given to the estimates of the utilities serving the region. These estimates were available to 1990.

Estimates of power requirements within the region are as follows:

Year	Energy (million kilowatt-hours)	Annual peak requirements including 20% reserve (megawatts)
1965	2,013	380
1980	5,770	1,300
2000	18,200	3,900
2020	36,400	7,900

In addition to the in-region demands, it is expected that plants in the region will be utilized to supply loads in the Pacific Northwest, eastern Colorado, the Midwest, eastern Wyoming, eastern New Mexico, Texas, California, the Lower Colorado, and the Great Basin.

A summary of in-basin demands plus reserves and exports is shown on Table 29. Projected water and land uses are shown on Tables 30 and 31. The water available for thermal-electric power generation was distributed among the states, having in mind the percentage distribution of their total uses under the Upper Colorado River Basin Compact.

Water quality, pollution control, and health factors

The difficulty of maintaining or restoring water quality is continually increasing because of the growing quantity of pollutants entering streams and the increasing depletions.

Although many situations can be met with existing knowledge, there is a continuing need for technological improvement in waste removal, treatment methods, and erosion control measures. In addition, there are situations for which the feasibility of solutions have not yet been determined. The control of salinity and mine drainage, for example, will require research and demonstration efforts to develop effective control measures.

Table 29 - Projected electric power capacity and generation, regionally interpreted OBERS level of development, Upper Colorado Region

Year	Local use	Areas exported to: Pacific Northwest	Eastern Great Basin[1]	Western Great Basin[2]	California	Lower Colorado	East[3]	Generation: Steam	Hydro	Total
				Installed capacity in megawatts						
1980	[4]1,300	1,500	1,459	31	2,900	5,700	1,810	13,400	1,300	14,700
2000	[4]3,900	2,000	5,259	31	9,700	12,900	9,610	42,100	1,300	43,400
2020	[4]7,900	2,000	8,059	31	7,600	8,200	9,610	42,100	1,300	43,400
				Generation in million kilowatt-hours						
1980	5,770	10,500	10,281	119	21,600	41,600	13,600	97,570	5,900	103,470
2000	18,200	14,000	39,201	119	68,800	88,600	72,000	295,520	5,400	300,920
2020	36,400	12,200	44,201	119	52,200	60,600	68,000	268,420	5,300	273,720

1/ Colorado River Storage Project (CRSP) plus steam generation.
2/ Colorado River Storage Project (CRSP) power to Mt. Wheeler Electric Association.
3/ Principally El Paso, Albuquerque, Denver, and midwestern United States.
4/ Includes 20 percent reserve.

Table 30 - Projected installed capacity and water depletions for thermal-electric power generation, regionally interpreted OBERS level of development, Upper Colorado Region

Subregion and state	Installed capacity and consumptive use					
	1980		2000		2020	
	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet
Green River						
Colorado	1,663	24.9	15,363	230.4	15,363	230.4
Utah	959	14.4	959	14.4	959	14.4
Wyoming	2,213	33.2	9,913	148.7	9,913	148.7
Subregion total	4,835	72.5	26,235	393.5	26,235	393.5
Upper Main Stem						
Colorado	123	1.8	1,613	24.2	1,613	24.2
Subregion total	123	1.8	1,613	24.2	1,613	24.2
San Juan-Colorado						
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
New Mexico	3,714	55.7	7,123	106.8	7,123	106.8
Utah	2,400	36.0	4,800	72.0	4,800	72.0
Subregion total	8,424	125.8	14,233	212.9	14,233	208.9
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	1,786	26.7	16,976	254.6	16,976	254.6
New Mexico	3,714	55.7	7,123	106.8	7,123	106.8
Utah	3,359	50.4	5,759	86.4	5,759	86.4
Wyoming	2,213	33.2	9,913	148.7	9,913	148.7
Region total	13,382	200.1	42,081	630.6	42,081	626.6

Table 31 - Projected land needs for electric power facilities for regionally interpreted OBERS level of development, Upper Colorado Region
(Unit--acres)

	1965	1980	2000 and 2020
Thermal powerplants			
Green River	162	1,650	7,400
Upper Main Stem	38	0	500
San Juan-Colorado	201	2,950	2,000
Subtotal (rounded)	400	4,600	9,900
Transmission right-of-way			
Upper Colorado Region	55,000	100,000	120,000
Total facilities (rounded)	55,000	105,000	130,000

Salinity

Future dissolved solids concentrations were estimated for 1980, 2000, and 2020. The impact of the OBERS level of development in the region is totaled at Lees Ferry, Arizona, where the TDS concentration, assuming no salinity improvement program, in 2020 is projected at 820 mg./l., or approximately 40 percent greater than the 1965 concentration. The major cause of the projected salinity increase is continued development of the region. It includes the additional stream depletions for irrigation, thermal-power production and exports, and the additional salts leached from newly irrigated lands.

Mine Drainage

In addition to eliminating fisheries and reducing the value of water for recreational purposes, mine drainage pollution in several areas also detracts from the value of streams as sources of municipal and industrial water supplies. Concentrations of some metals periodically exceed Public Health Service limits for drinking water supplies. In some cases costly treatment is required to make the water suitable for industrial purposes.

More demands will be made of the streams of the area, especially by the ever-increasing number of recreationists. The present and future needs for high-quality water can be aided if mine drainage is controlled.

Wastewater Treatment

Many changes have occurred in water pollution control in the period from 1965 to 1970. Even with this progress, there still remains in 1970 a need for further improvements in wastewater treatment to control existing sources of pollution. There is also a significant need for improved operation and maintenance of existing wastewater treatment systems.

As a result of the expected population growth and economic expansion, future discharges to municipal and industrial wastewater treatment works are estimated to triple from 11,400 to 34,900 tons biochemical oxygen demand during the 1965-2020 period.

In critical areas, especially near some recreational lakes, there will be a need by 1980 to remove significantly larger percentages of nutrients from municipal wastewaters by tertiary treatment methods in order to prevent accelerated eutrophication of these water bodies.

The sprawling construction of recreation homes and commercial enterprises has resulted in the proliferation of individual and small community disposal systems in some recreation areas. Because of the rapid growth in recreation, detailed basinwide water quality planning is urgently needed in these areas. In addition, recent legislation requires that wastewater treatment works be in conformance with a basin or regional plan to be eligible for Federal financial assistance.

Use and Management

Opportunities to improve water quality through careful land management appear to be of the utmost significance. Land use and management activities are known to contribute to water quality problems. Sediment and inorganic salts and minerals have a primary impact on water quality. Animal wastes, agricultural chemicals, infectious agents, turbidity, and heat are also of concern. Various aspects of the effects of land use are outlined in the technical appendices. Any of the land management practices could possibly cause one or several changes in the quality of water. Some of these activities have both plus and minus effects on water quality. Certain associated conservation measures can and do abate pollution and improve water quality. The net effect of land use and management, however, is not fully understood.

Since the largest percentage of salt accretions contributing to salinity are from diffuse sources of geologic origin and irrigation return flows, potential salinity control benefits from improved land management practices should be fully evaluated.

Streamflow Management

Water quality improvement by means of streamflow management is limited in the Upper Colorado Region under present legal and institutional environments. The maintenance of minimum flows for water quality purposes is not recognized as a beneficial use of water in the water rights laws of any state in the region. Availability of water in streams to maintain water quality depends exclusively on flows released to meet other downstream uses. Under existing laws, the entire flow of a stream could be periodically removed leaving the stream dry regardless of water quality criteria. Therefore, management of streams to insure minimum flows for

water quality control is contingent upon purchasing existing water rights or importations.

If water quality control becomes recognized as a legitimate use, water resources management could provide for the optimum combination of quality and quantity for the available supply. In considering a streamflow management program, the effects of stream regulation on an entire river basin would have to be an integral part of any regionwide or basinwide water quality management scheme.

Environmental Health

There is a great need for additional protection and surveillance programs to safeguard domestic water supplies. Adequate control and surveillance programs are needed for the problem areas of air pollution, solid waste disposal, radiological pollution and disease vectors.

Thermal Power Production

In the past, waste heat output has not multiplied as fast as power generation because of continued improvements in thermal plant efficiency. Fossil-fueled plants are reaching a limit of efficiency; waste heat to cooling systems can be expected to more closely parallel power production increases in the foreseeable future. The heat expelled to cooling systems is estimated to increase from about 5,400 million B.t.u. per hour in 1965 to 127,100 million B.t.u. per hour in 2020.

The selection of appropriate sites for locating powerplants so as to minimize environmental effects poses a significant challenge to both the industry and Government. Environmental concerns will necessitate the consideration of many more factors in the planning of power production facilities than has been the practice in the past. In addition to thermal pollution control, a number of other selection factors make siting very complicated--esthetic impact, availability of water supply, safety, air pollution control, access to transportation and others. Installation of facilities, such as cooling towers to control thermal pollution will affect cost factors and require more space for the plant and may make it more difficult to meet esthetic goals. Siting is likely to become an increasingly difficult and controversial factor in the continued growth of power production.

State-Federal Water Quality Standards

The water quality standards established by the states and approved by the Secretary of the Interior in accordance with the Water Quality Act of 1965 represent a major step in water pollution control. The standards and implementation plans are means for controlling pollution. Expansion of the standards to include intrastate streams is needed where this has

not been done. Also, the water quality criteria should be expanded to cover additional parameters in order to provide a more complete measure of water quality.

Pollution Surveillance

Data describing wastewater and stream quality conditions are limited. Expansion of present programs is needed in order to provide better stream coverage and to measure additional water quality parameters. A thorough knowledge of water quality conditions, waste loadings, and streamflow characteristics will permit the utilization of computerized mathematical modeling as a tool for better water quality management.

PART IV

PRESERVATION CONSIDERATIONS

"Preservation of resources in appropriate instances to insure that they will be available for their best use as needed" is part of the basic objective of the study. Preservation in this sense can be defined as protection from injury or destruction. The purpose in making the consideration is to provide for the timely development of the resources and to insure the well-being of all the people which is also part of the basic study objective. Preservation does not infer nonuse or "locking up" resources. Instead it indicates the existence of values which may be irretrievably lost unless careful coordination of resource use and development is made. Thus, the preservation of future development opportunities as well as protection of natural and cultural values is included.

This part provides a broad overview of the preservation considerations of several major resources in the region. Maps showing the resource protection needs, together with the Stream Environment Profile, are designed to draw attention to the interfaces among the resources. Each of these interfaces creates either an opportunity for joint benefit or a conflict between resources. When several resources occur in a common area, their preservation requirements may present a complex set of opportunities and conflicts. Further study in more detail will normally be required to satisfactorily provide the necessary protection to the resources involved in such instances.

Preservation Needs

Crop production

Preservation considerations relating to croplands include those pertaining to the presently used area and to the potentially usable area.

Currently 1,621,500 acres are being used for irrigated crop production plus 603,000 acres for dry crops. These areas and their water distribution systems are subject to loss through urban expansion, transportation system extensions, and other intensive land uses. These areas are generally among the highest value croplands and any diminution of their size poses a serious production loss problem.

The 7,058,600 acres of potentially irrigable land and the reservoirs and distribution systems needed to serve any of those lands that may be developed are another consideration if future developmental opportunities are to be maintained.

PART IV

PRESERVATION CONSIDERATIONS

Early developments, particularly irrigation projects, were not faced with competition for land, nor required to include land costs for public lands developed. The present situation is far different with almost all of the potentially irrigable lands presently being used for one or more other uses. Adding to this land use competition problem is the requirement to include all costs of eliminating other uses when new irrigation projects are installed. Therefore, it is imperative that the location and value of the potentially irrigable lands be identified so that other land uses will not eliminate developmental opportunities.

The problem in identifying and preserving future developmental opportunities is compounded by the present lack of data identifying which areas are the most valuable. Whereas, it is known that about 90 percent of the entire 7,058,600 acres probably will not be used under present inventories, it is not possible to refine the preservation requirements by delineating the most valuable 10 percent.

The presently used and potential areas are included on the Preservation Areas Map following page 94. Potential selected reservoir sites are identified on the Stream Environment Profile.

Livestock grazing production

Approximately 54,600,000 acres are suitable for grazing. Few of these acres individually require protection from other uses to maintain the overall productivity of the resource. This does not imply that the grazing resource is not vulnerable to damage by other resource uses.

Grazing by livestock is the only known means of converting much of the vegetation in this arid region to products economically usable by man. Range-grazing productivity depends upon the continued ability to use extensive areas of land without severe restriction. This occurs because the output per acre is not high and thus range livestock grazing cannot compete if competition becomes too severe. Under this set of constraints the preservation consideration necessary is to plan for grazing use, together with the other uses of the land base to maintain economic feasibility for grazing.

The area suitable for grazing and requiring protection is not shown on the map. A general indication of the location can be obtained by referring to the vegetal cover maps. Alpine, barren, and urban provide little or no grazing use, while the range type provides the most. Forest-type grazing productivity is inversely proportional to the density of the stand.

Timber production

There are 9.4 million acres of forest land which are capable of producing timber products of commercial size and quantity. Current proposals

for wilderness would result in further loss of commerical forest acreage. The current projections of acreage to be lost to highway construction, utility corridors, reservoirs, summer home development, etc., are approximately 234,000 acres. Unofficial estimates place the potential loss in acreage due to all causes in the 30 to 40 percent range.

Large losses of commercial forest acreage would seriously affect the region's capability to meet future needs of timber products. Therefore, considerations for conversion of commercial forest acreage to other uses should be carefully evaluated as to all values to be gained or foregone by conversion.

The general area of commercial forest is shown on the Preservation Areas Map.

Mineral production

Estimates of the increase in land needed for active mineral industry operations jump from 37,000 to 178,000 acres by 2020.

Preservation of exploration opportunities for minerals is the most important consideration to insure future productivity. As land use intensifies, the physical and legal restraints on this activity could become excessive.

Exploration is essential because normally only a 10- to 20-year reserve of most minerals is maintained. These areas and the areas containing the more valuable presently known deposits of mineral wealth are broadly identified on the Preservation Areas Maps.

Electric power production

Projected energy production indicates an increase from 7,356,000 million kilowatt-hours in 1965 to 273,720,000 million kilowatt-hours in 2020. This includes local use and export. To meet this load, it is expected that 13 large steam-electric plants totaling 40,800 mw. will be built in the region. The transmission right-of-way requirements will increase from 55,000 acres in 1965 to 120,000 acres in 2020. Land required for powerplant facilities will increase from 400 to 9,900 acres for the same time frames.

Land requirements for electric power generating plants depends on (1) size and type of plant, (2) location, (3) on-site needs for fuel storage and handling facilities, and (4) method of disposal of waste products.

Land use for transmission line rights-of-way will not always conflict with other beneficial uses since activities such as farming or grazing will be compatible to a degree. The most serious problem will

occur where the lines cross close to recreation areas, wilderness, wild rivers, or highway routes. General routes of utility corridors which may conflict with other uses are depicted on the Preservation Areas Map.

Flood control opportunities

Flood control and flood damage prevention programs are classified under two general headings--corrective and preventive measure. Corrective measures having preservation requirements include: dams and reservoirs, levees or walls, channel improvements, and watershed treatment. The opportunity to install these practices partially depends upon the use and development of the stream channels.

Reservoirs are considered to be the most effective measure for the control of floods in many of the problem areas in the region. Few single-purpose flood prevention structures are anticipated; however, the opportunity to add incremental storage to multiple-purpose reservoirs must be preserved if flood control is to be effective. Selected sites, together with other structural opportunities, are shown on the Stream Environment Profile.

Preventive measures having preservation requirements include flood-plain zoning and other use restricting regulations in flood-prone areas. The flood-plain management in conjunction with streamflow forecasting program offers opportunity not only for flood damage reduction but can also provide additional "Green Belt" areas in or near cities.

Recreation

Since the beginning of civilization, man's efforts to control his environment have produced many conflicts with nature. At the same time, these efforts have been rewarded with the opportunity to live in varying degrees of comfort almost anywhere he chooses. However, where man has altered or conquered nature, he has often destroyed that which he can never replace.

In the past, the exploitation of natural features and values was defended by assigning priorities. However, the rapidly dwindling reserve of outstanding natural features and the development of new value systems have made it mandatory that priorities be reassessed and determined in a more comprehensive manner. Under this broader system of determining priorities, every effort must be made to husband those limited outstanding natural resources which still remain.

As inferred, water and related land resource developments greatly alter the natural environment. This is especially true of all structural modifications. When flood plains and bottom lands are converted to lakes by reservoir developments, the ecology of downstream areas is altered. Most such measures also cause change because of their influence on social-economic conditions in the areas where they are located.

PART IV PRESERVATION CONSIDERATIONS

Natural values worthy of preservation include topographic or hydrographic features and/or the fauna and flora they support. Physical features may be valuable only because of what they are or because of what they support. This value, often not apparent or readily measurable in tangible terms, nevertheless increases with the uniqueness of the feature under consideration.

Specifically, the Upper Colorado Region is one of the last remaining areas containing unique natural features that still are relatively unspoiled. For this reason, and because future developments and use may also eliminate or despoil these areas, a very careful analysis must be made of both tangible and intangible long-range benefits and disbenefits that may result from planned developments or uses.

Within the region numerous areas have been identified as worthy of consideration for preservation. These have been enumerated in tables contained in Appendix XII, "Recreation," within the section on potential outdoor recreation areas. The areas of special concern are related to areas where interests conflict. Some of the most important are shown on the Stream Environment Profile and the Preservation Areas Map. It should be understood that because of generalization and lack of data this is only a partial list. A dam at the Marble Canyon site as identified in the Lower Colorado Framework Study would affect part of the potential scenic river area between Glen Canyon Dam and the region boundary. Tributary streams, such as the Crystal and the Paria, also may have conflicts. On the Green River, the Kendall Dam would inundate part of the potential wild river segment below Green River Lakes. Other conflicts may occur in connection with the Swallow Canyon powersite in the potential wild river segment below Flaming Gorge Dam and the Gray Canyon powersite on the potential scenic river segment north of Green River, Utah. On the San Juan River, the Chinle Unit and the Mexican Hat Project would affect the potential scenic river status of the river between Cottonwood Wash and Slickhorn Creek. Several dams are proposed on the Gunnison River below Morrow Point Dam. Much of the affected area of this river has potential for wild river designation. On the Yampa River the proposed Juniper powersite would affect the potential recreational river designation of the area below the confluence with Fortification Creek.

The above discussion has indicated only a need to protect natural features. Similar need, however, applies to protection of areas that have archaeological, historic, scientific, and educational values. A partial list of these kinds of areas is included in Addendum E of Appendix XII, "Recreation."

It is apparent that both conflicts and opportunities may be associated with preservation of some, or all, of the areas listed in Appendix XII, "Recreation." The decision to save these resources as they are, or to modify them to fit more utilitarian needs is one of the major choices involving the Upper Colorado Region. Decisions to utilize or

preserve these resources will depend in large measure on best judgment and national goals. The fine balance that exists betweem man and his environment could easily be upset if decisions to exploit the remaining natural resources are merely based on their inherent economic values.

Fish and wildlife

The region should be kept replete with a full complement of animal life. Preservation of quality habitat is also a must, not only for the fish and wildlife, but for the special enjoyment of unspoiled environment by the people who will hunt, fish, or watch in our animal world. The special qualities merit unslacking preservation efforts and also contribute substantially to the important economic values associated with enjoyment of fish and wildlife in the region.

This is particularly significant for the rare and endangered species. Most of the endangered or rare forms of fish and wildlife in the region have extensive potential ranges or are migrating birds. A few animals, however, are confined to particular habitats which should be preserved. The humpback chub and the Colorado River squawfish live upstream from Lake Powell to Dinosaur National Monument in the Green River and to the Grand Junction area in the Colorado River. The Kendall Warm Springs dace is confined to only 200 yards of warm spring flow adjacent to the Green River in Wyoming.

Appendix XIII, "Fish and Wildlife," includes a selection from the hundreds of miles of fine quality trout streams in the region. These are the streams that should be accorded special significance in water development planning with a view to their preservation. Some of the best known examples are the Green, White, New Fork, and Strawberry Rivers in the Green River Subregion; the Colorado, Roaring Fork, and Gunnison Rivers in the Upper Main Stem Subregion; and the San Juan and Animas Rivers in the San Juan-Colorado Subregion.

The needs for wildlife habitat extend to the preservation of much of the key habitat which was described in the foregoing section on Regional Needs and Demands. These areas are shown on maps in Appendix XIII, "Fish and Wildlife," for mule deer, elk, moose, antelope, bighorn sheep, sage grouse, turkey, and waterfowl. Any planned developments or changes in management in these areas should recognize the need to preserve important parts for wildlife. These wildlife areas are combined and shown on the Preservation Areas Map. The fishery, waterfowl, and other water-oriented preservation considerations are similarly identified on the Stream Environment Profile.

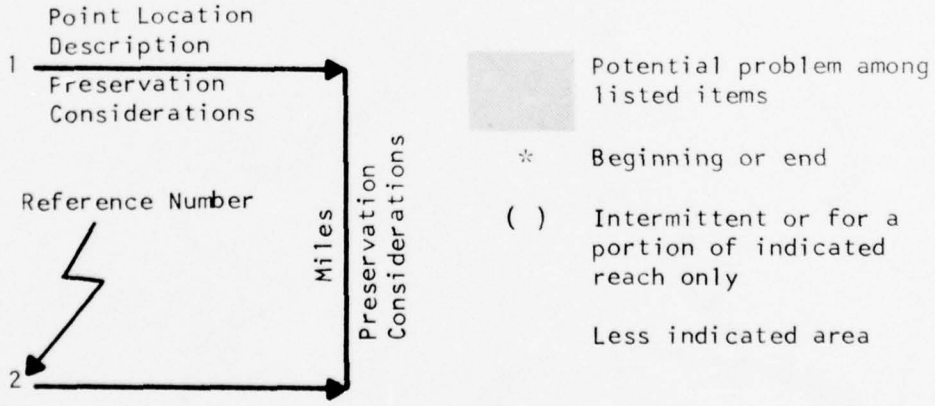
Stream Environment Profile

The purpose of this profile is to help identify the potential problems and the compatible development opportunities along the streams. Reaches of the stream having potential problems based upon identified preservation considerations are highlighted with a shaded overprinting. These areas particularly should receive a more detailed analysis before developmental proposals for any of the uses are made. No indication of the magnitude of potential problems or opportunities is attempted here. In some cases, however, the very significant problems and opportunities are covered in the individual narrative portion of this section or in the several corresponding appendices.

Five major streams are included in this profile analysis. They are the Colorado, Gunnison, Green, Yampa, and San Juan. Preservation considerations are indicated for the various resource values lying within the stream environment. Supplementary data for selected tributaries or parts thereof are listed; however, the precise location of each consideration is not shown nor is the mileage of the tributary.

EXPLANATION

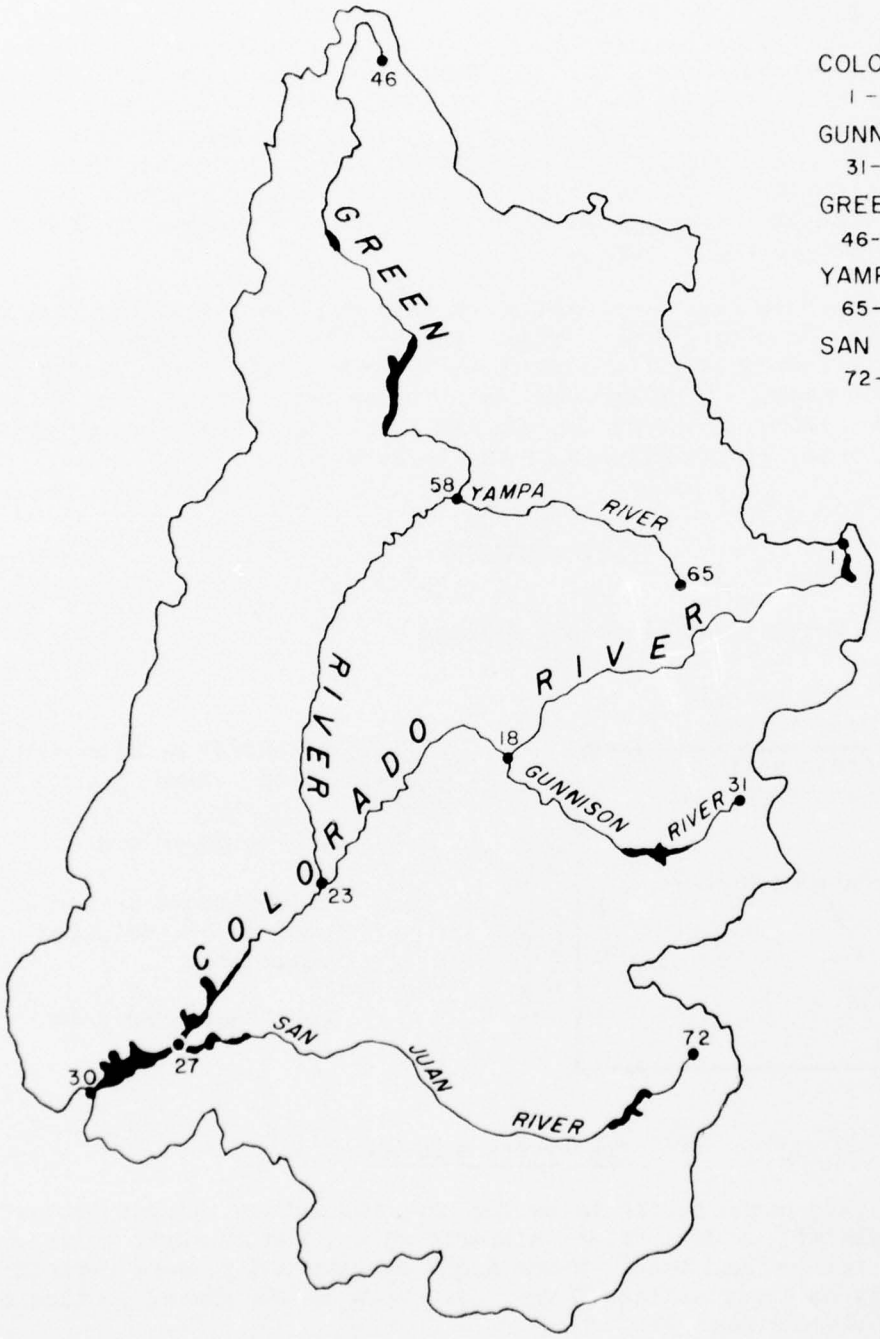
RIVER NAME, Reach Identification, Mileage



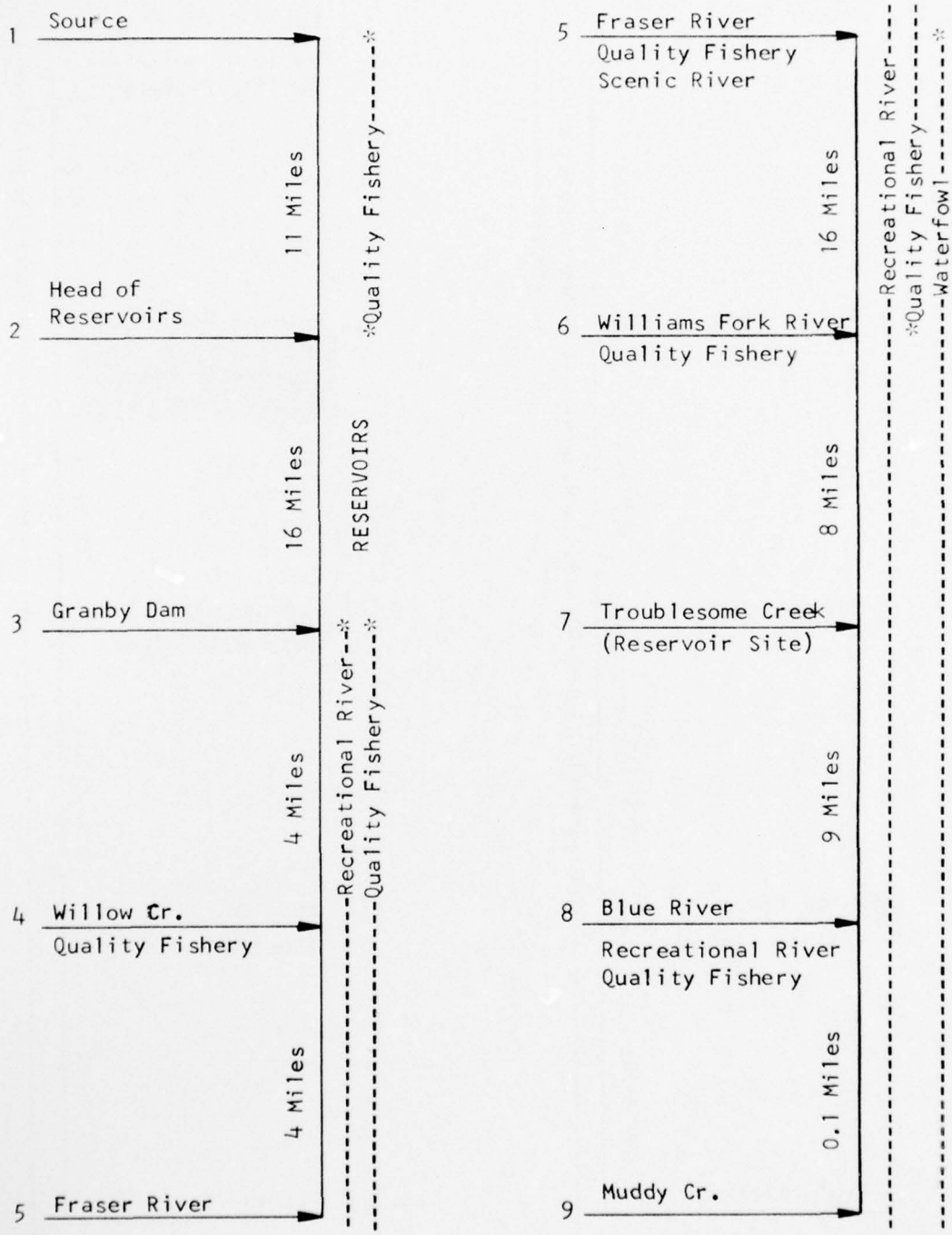
Preservation Areas

Identified areas having value for crop production, timber production, wildlife habitat, natural value, historic value, and cultural value occupy nearly the entire land base. These areas overlap and present certain problems as well as opportunities. They are shown on the shaded portion of the maps following page 94.

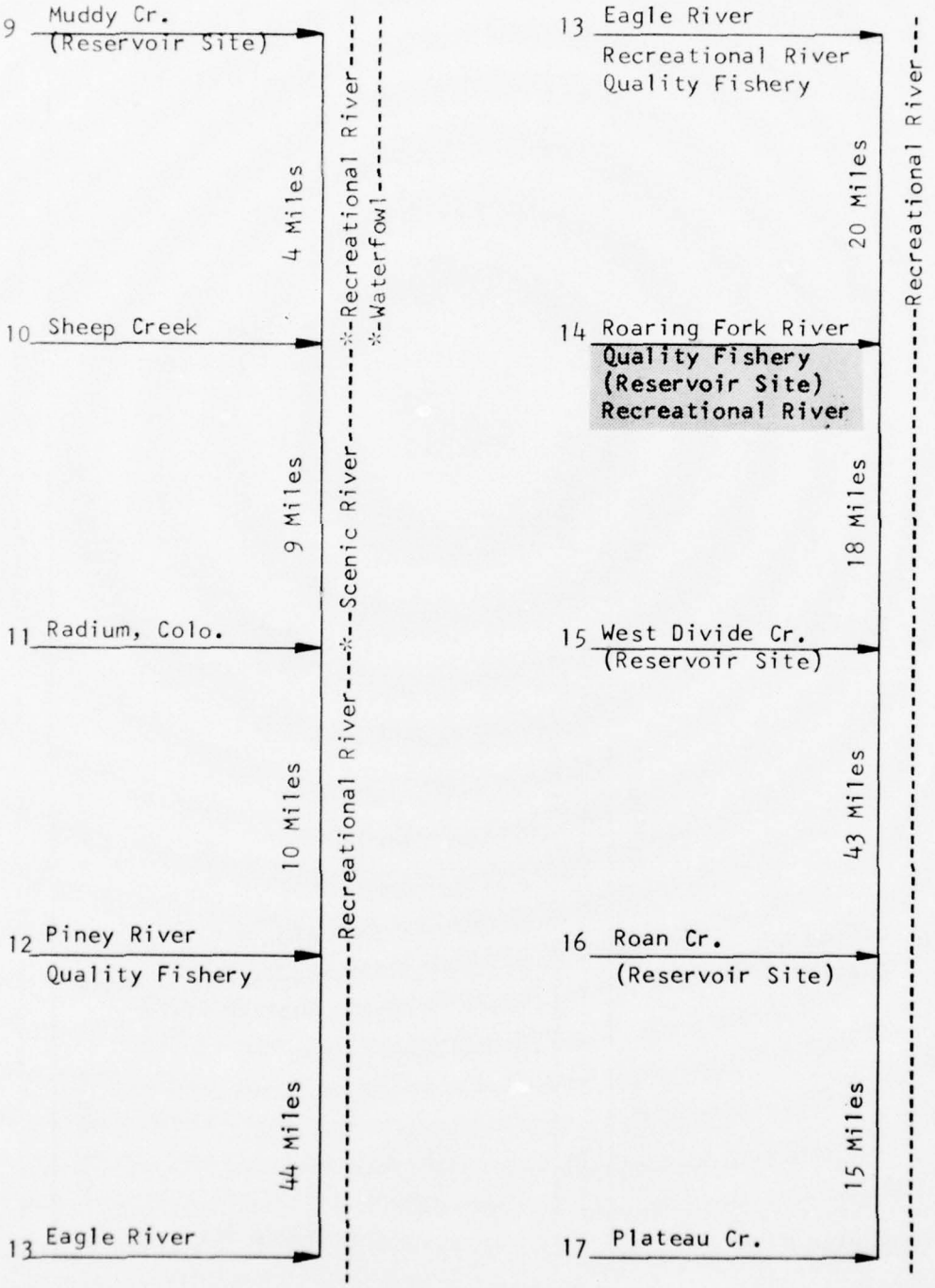
UPPER COLORADO STREAM PROFILE REFERENCE KEY



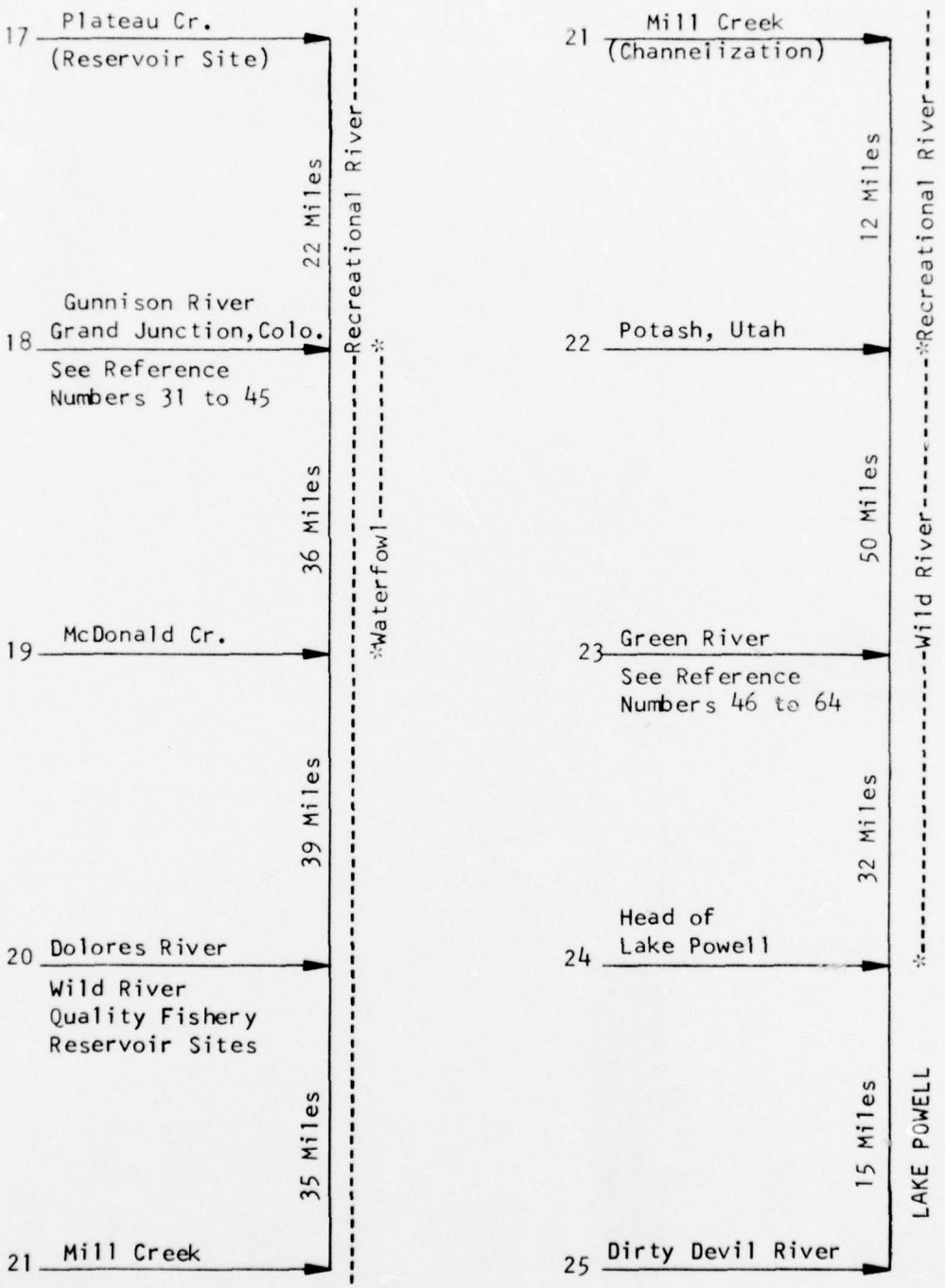
COLORADO RIVER, Source to Muddy Creek, 68 Miles



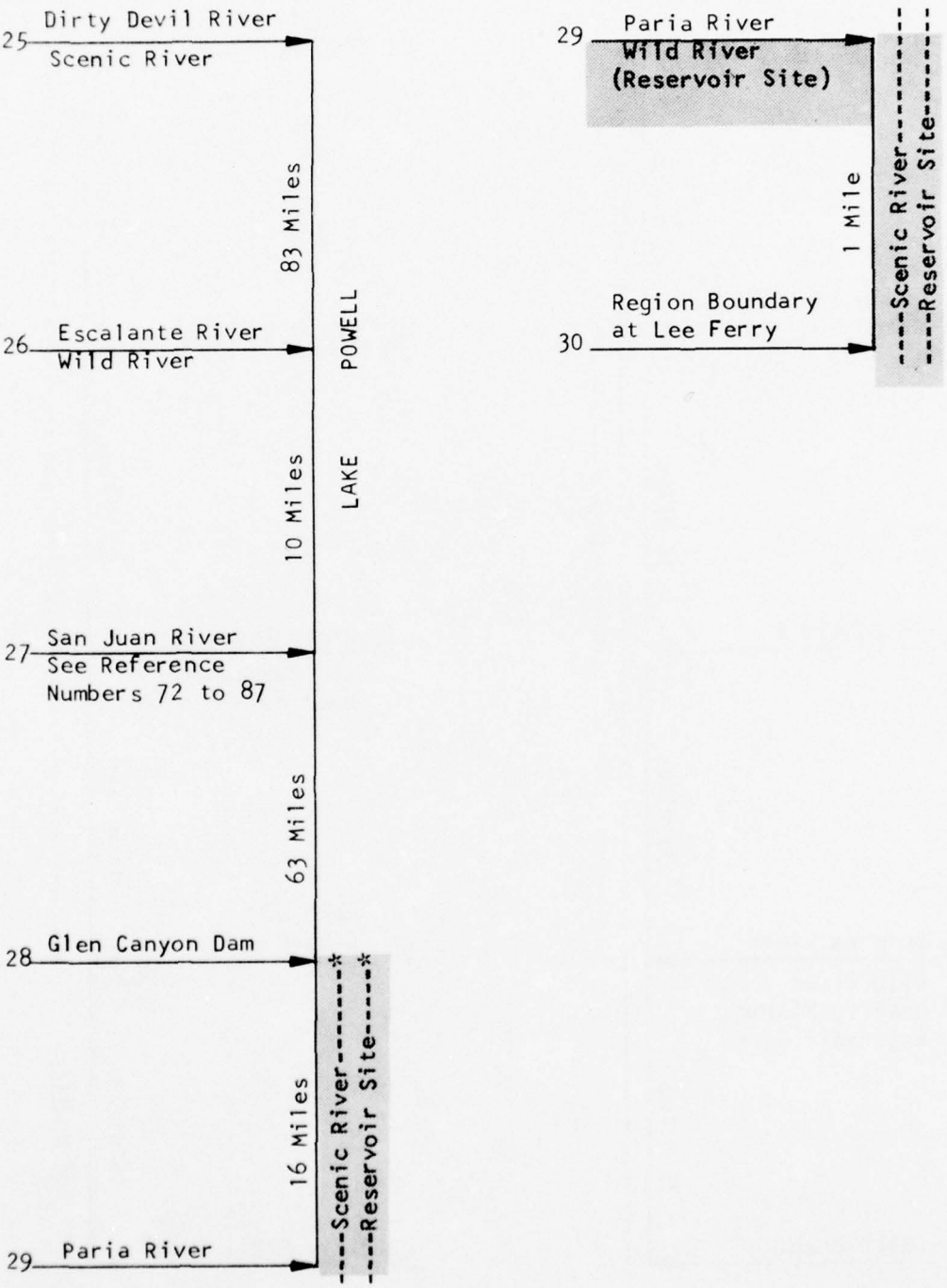
COLORADO RIVER, Muddy Creek to Plateau Creek, 163 Miles



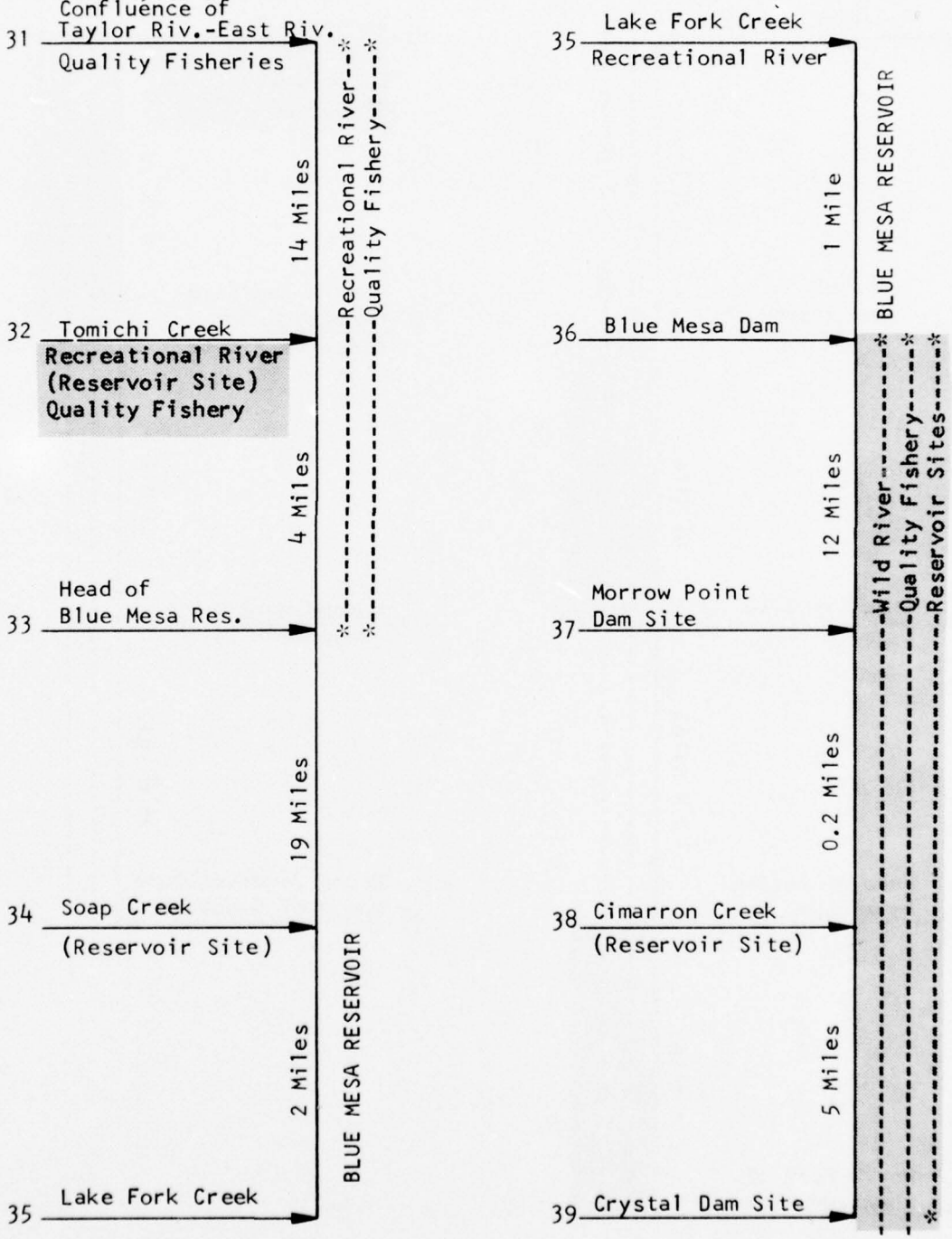
COLORADO RIVER, Plateau Creek to Dirty Devil River, 241 Mi.



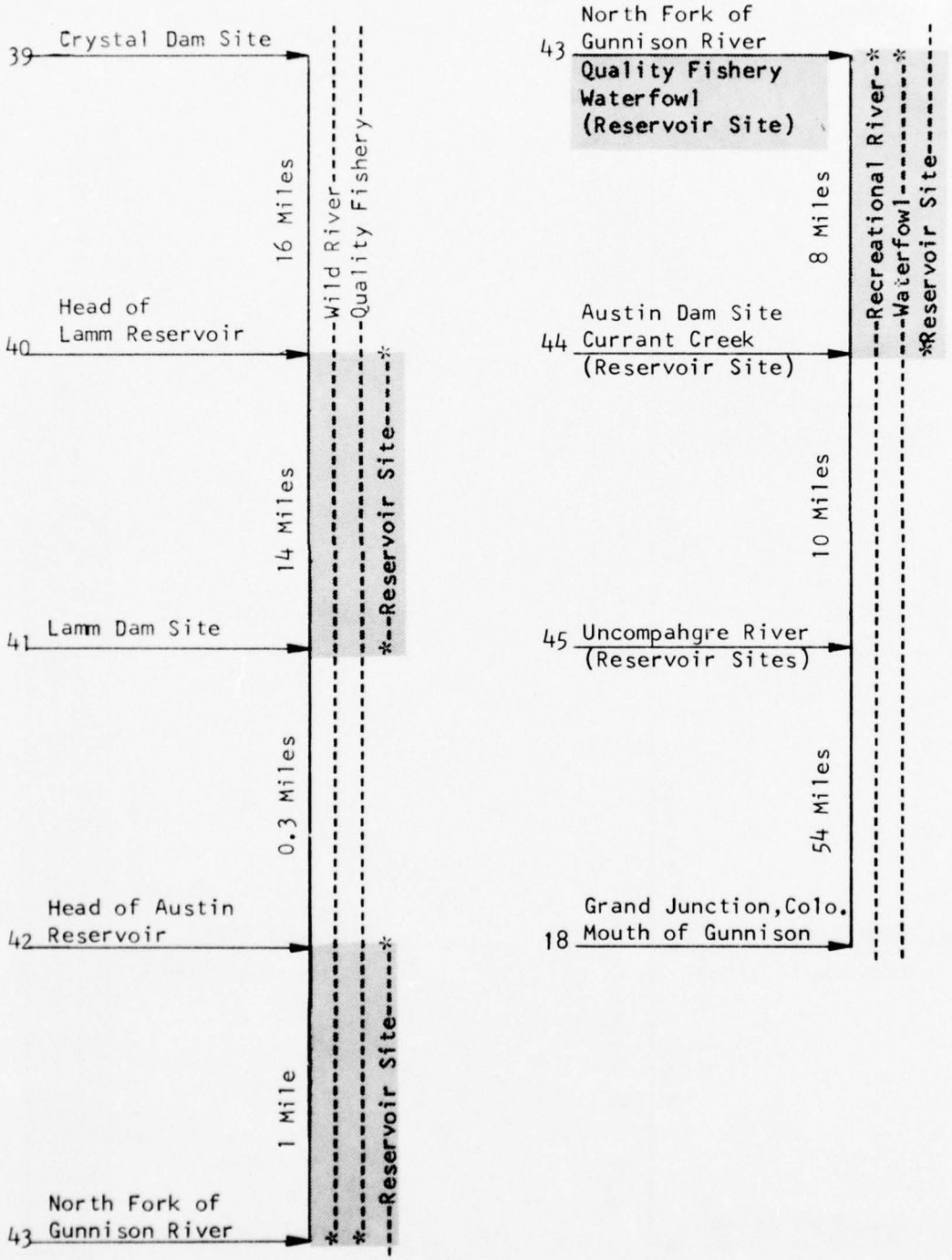
COLORADO RIVER, Dirty Devil River to Region Boundary, 173 Mi.



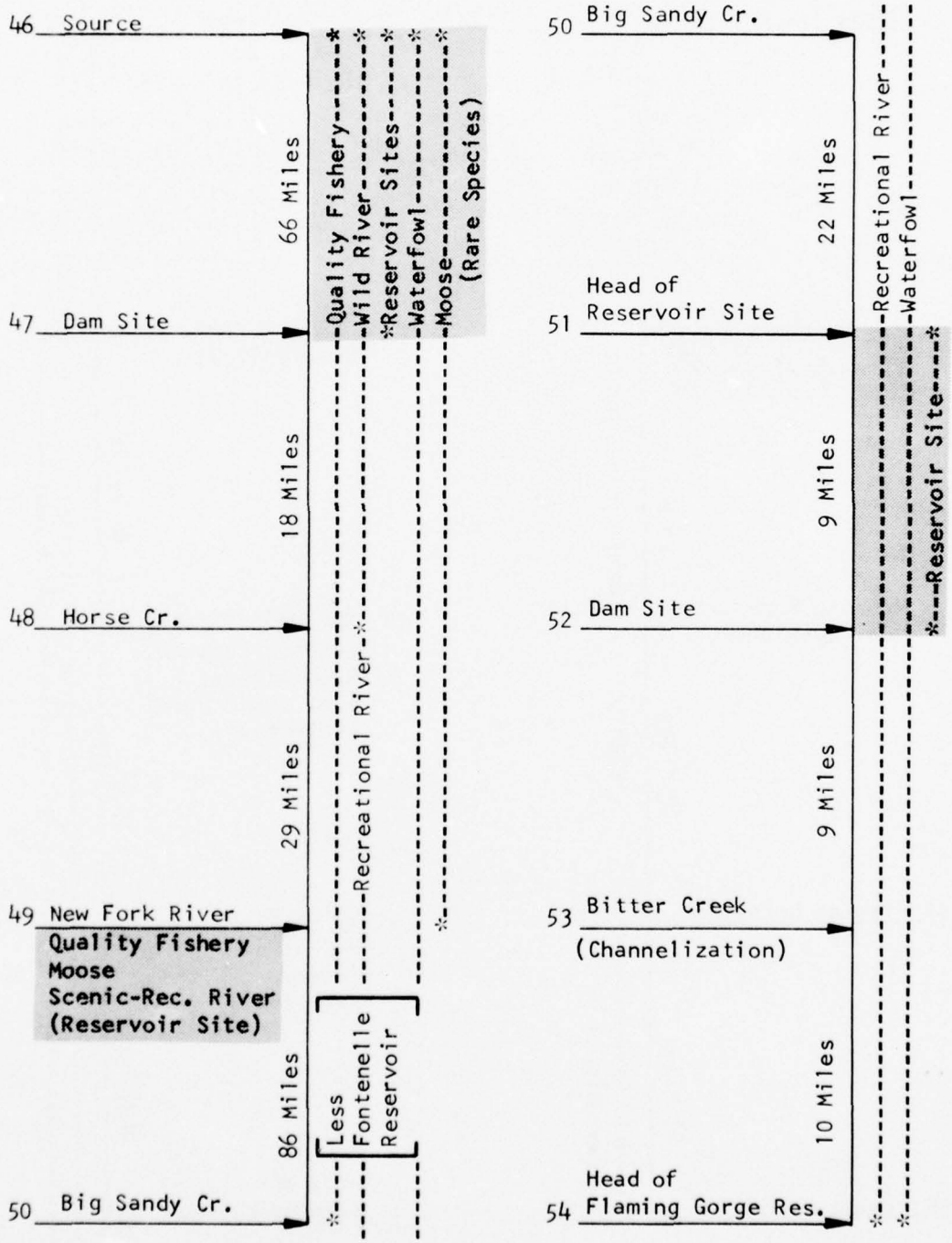
GUNNISON RIVER, Almont, Colo. to Crystal Dam Site, 57 Miles



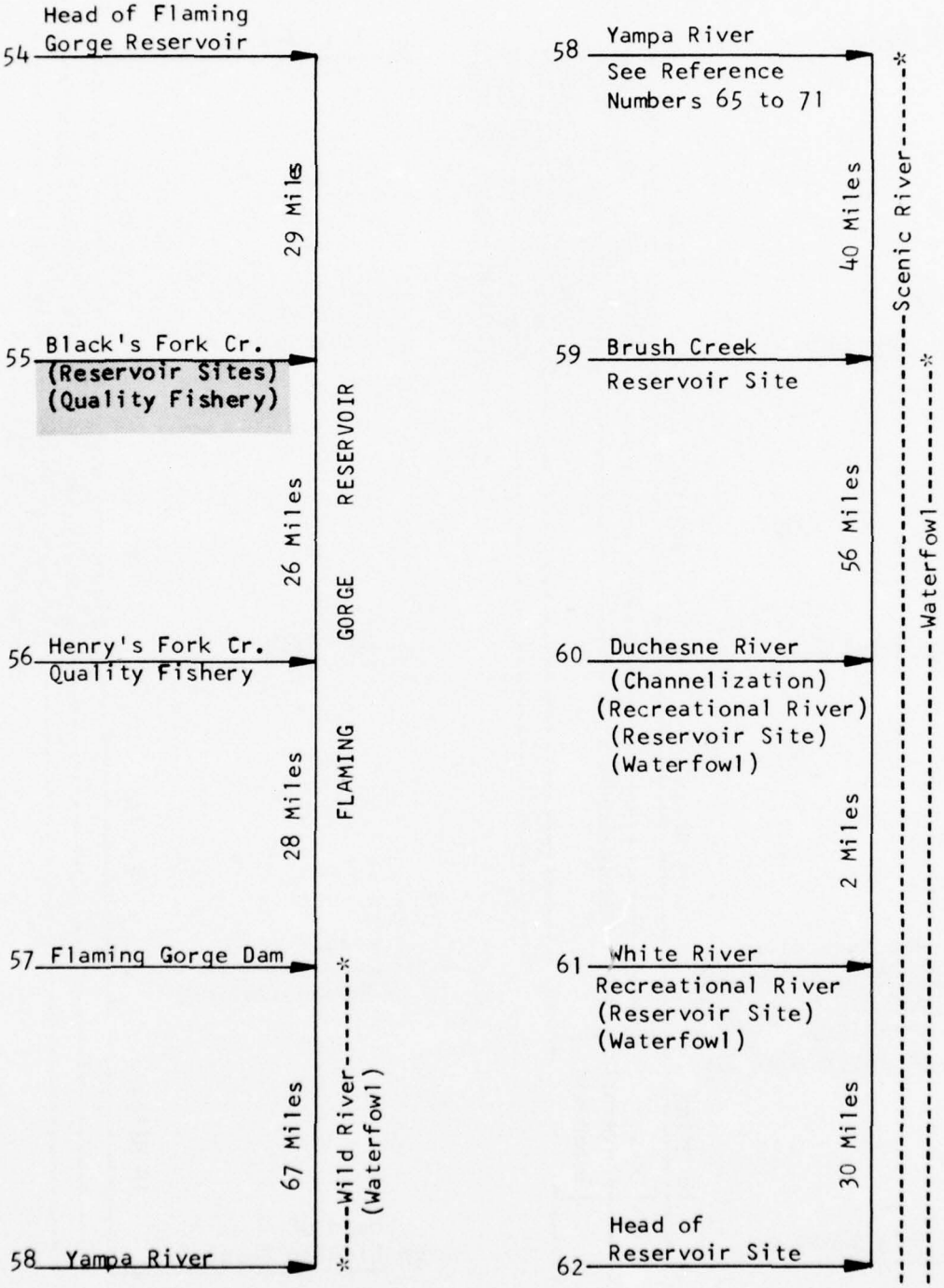
GUNNISON RIVER, Crystal Dam Site to Mouth, 103 Miles



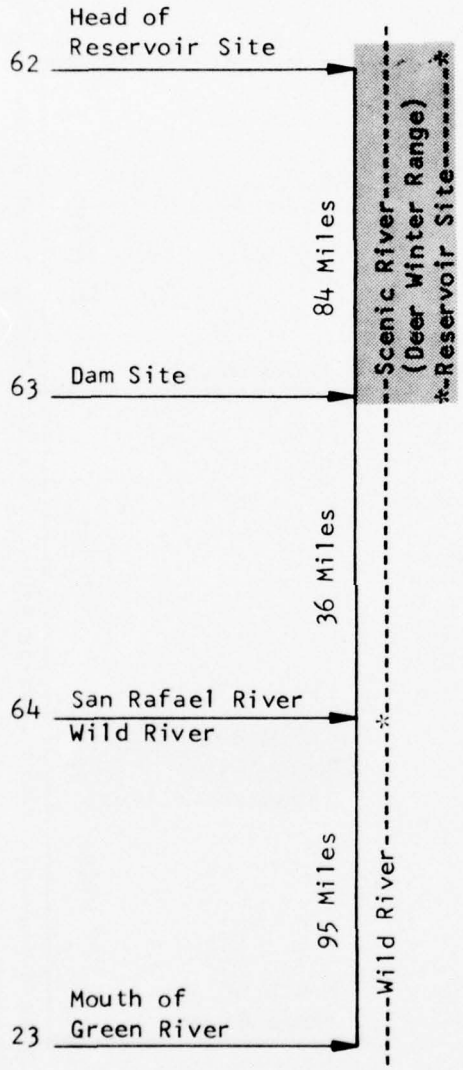
GREEN RIVER, Source to Head of Flaming Gorge Reservoir, 249 Miles



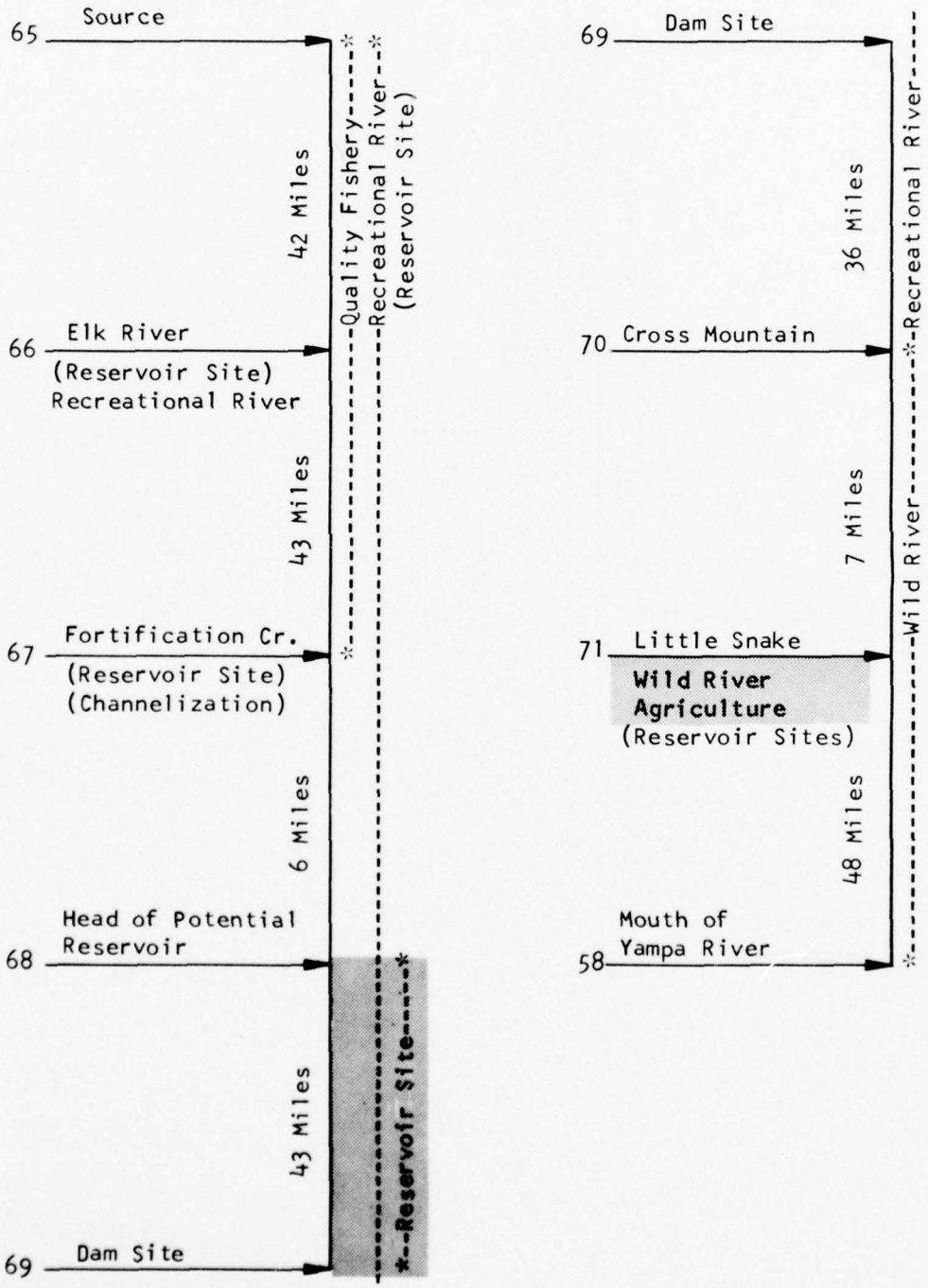
GREEN RIVER, Head of Flaming Gorge Reservoir to Yampa River, 278 Mi.



GREEN RIVER, Head of Reservoir Site to Mouth, 215 Miles

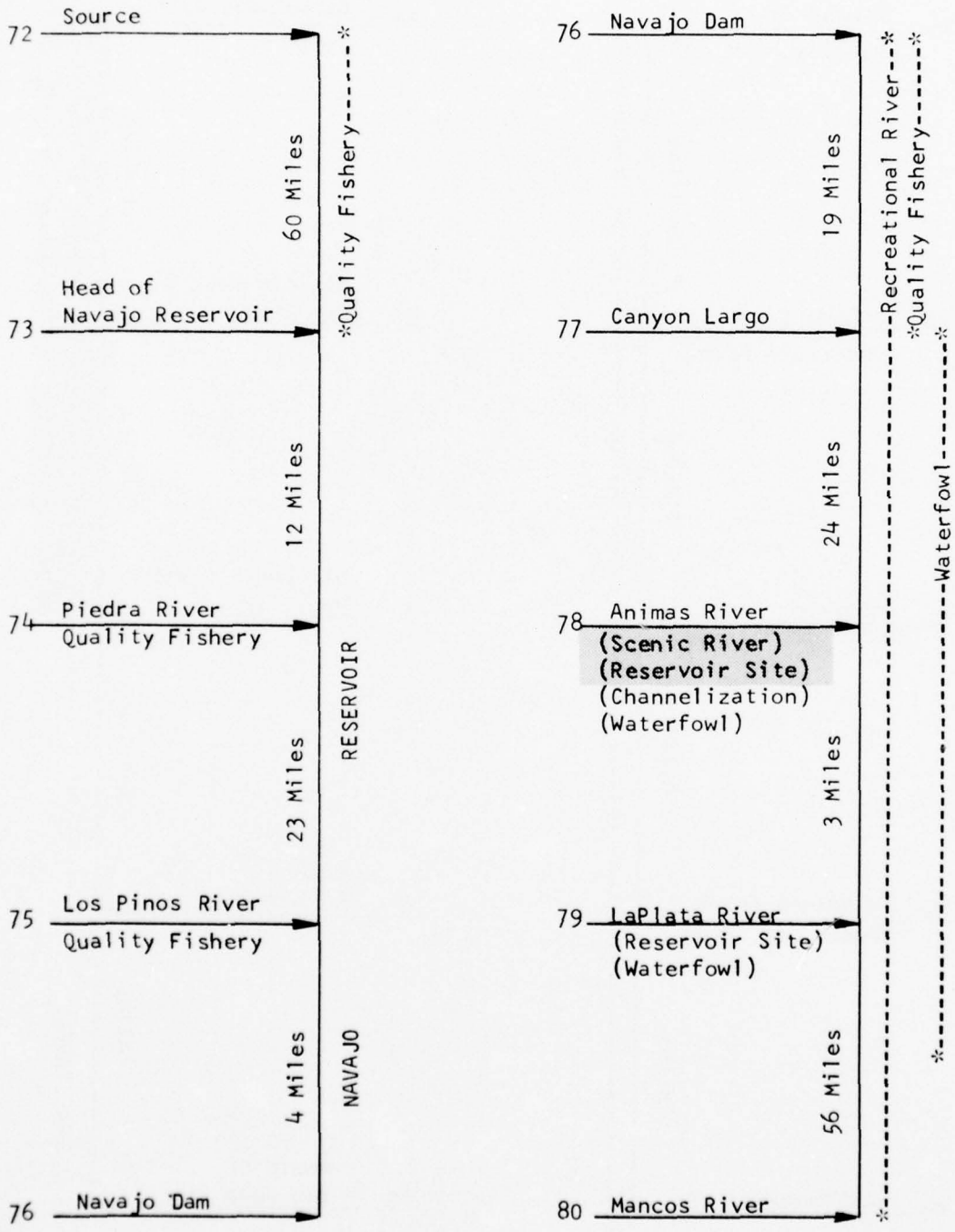


YAMPA RIVER, 225 Miles

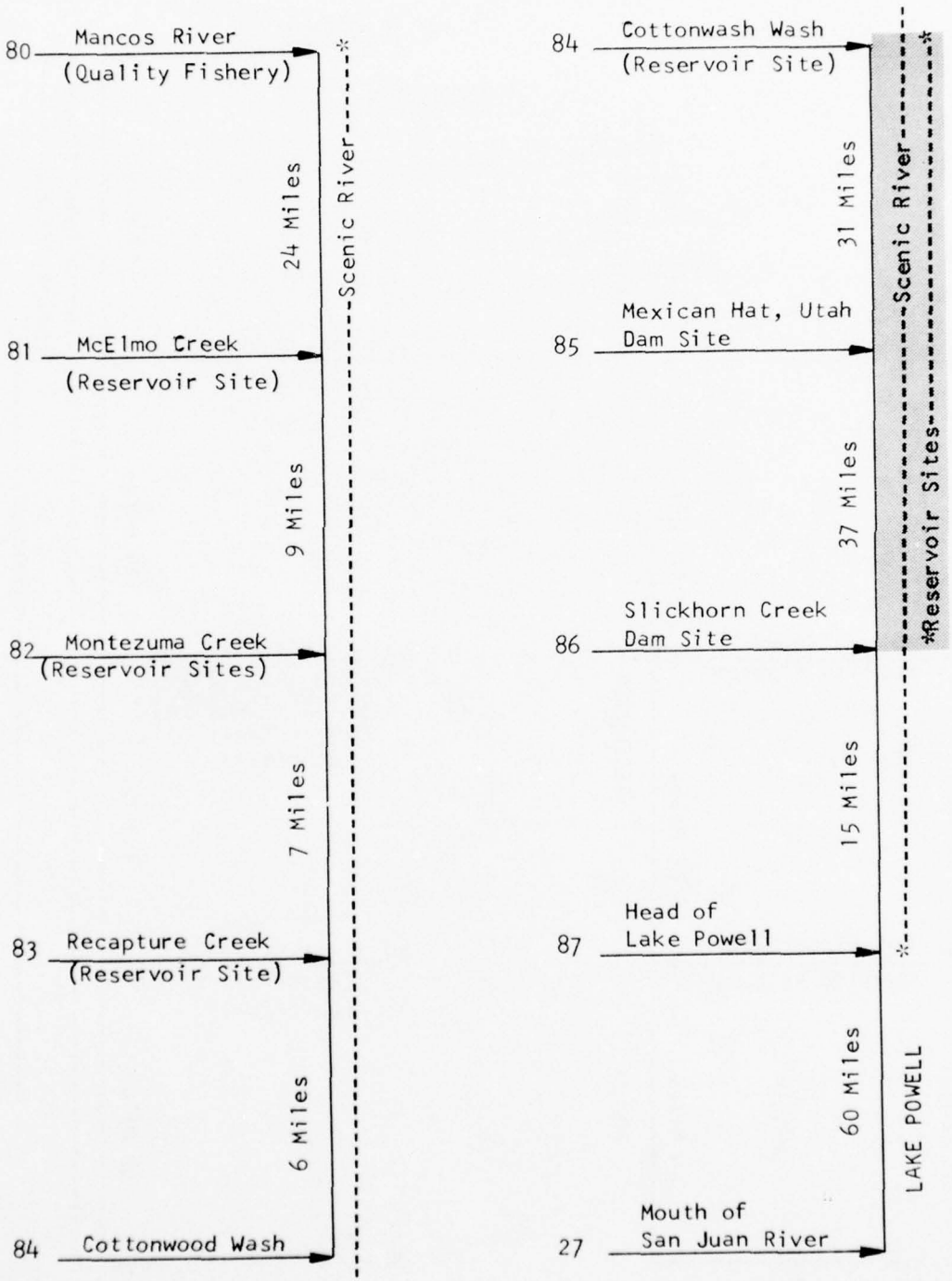


PART IV PRESERVATION CONSIDERATIONS

SAN JUAN RIVER, Source to Mancos River, 201 Miles



SAN JUAN RIVER, Mancos River to Mouth, 189 Miles



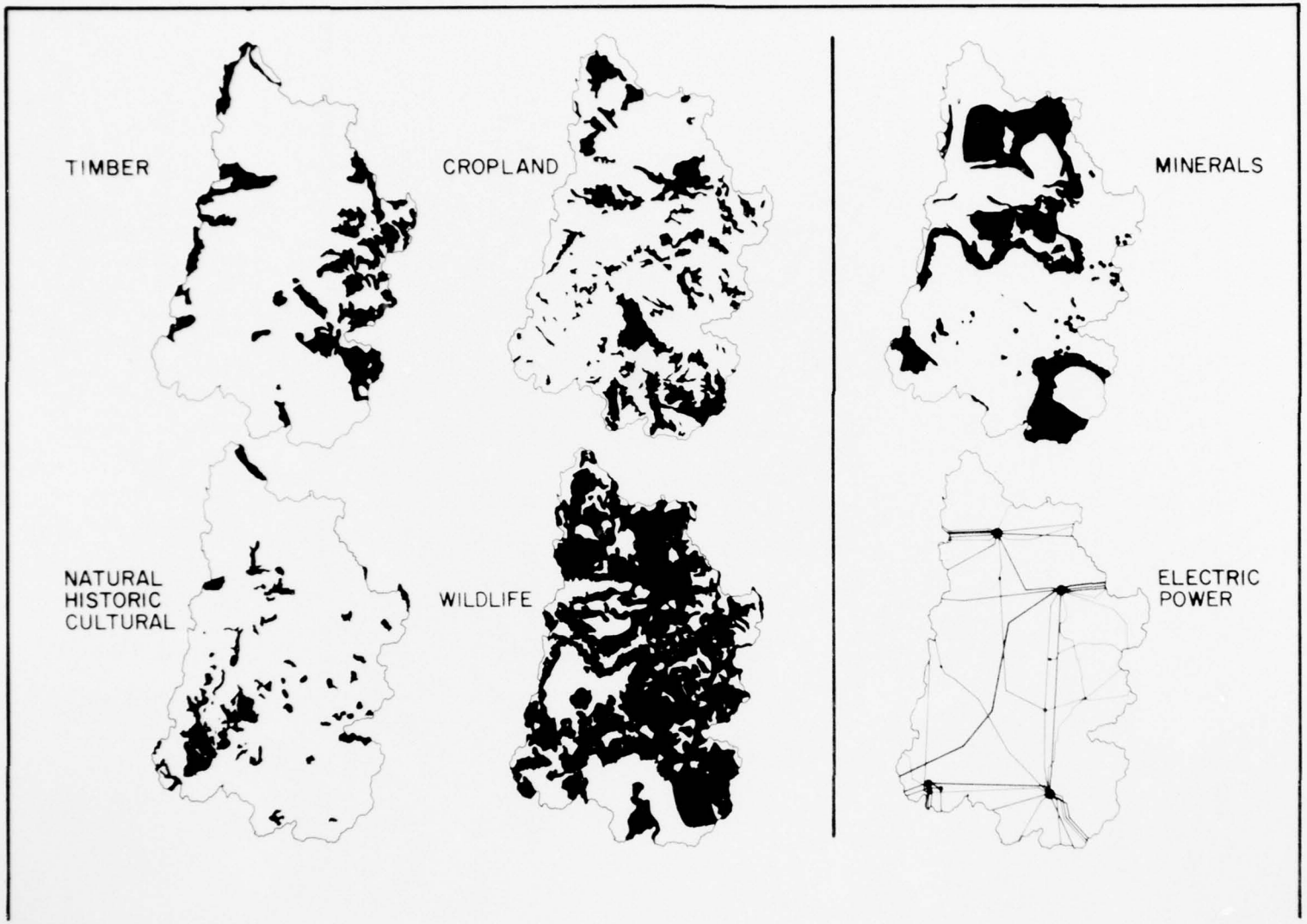
Identified areas having value for mineral production and electric power production are not depicted on the main map due to the fact that precise data regarding their location is not readily available.

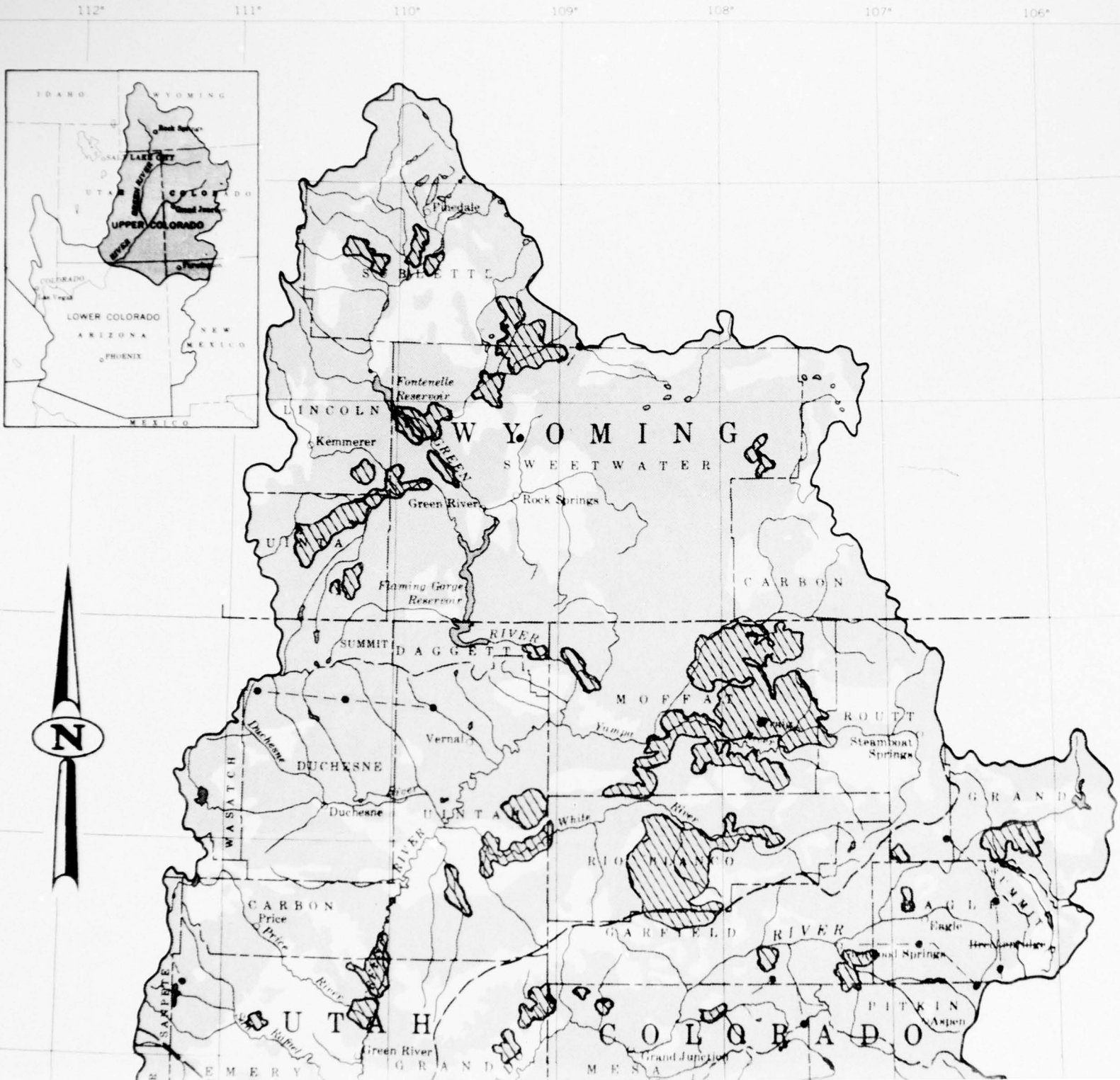
Potential conflicts among all of the above values are generally indicated on the main map. It was generally assumed that potential conflicts would most likely occur between certain pairs. Judgments were applied to modify this basic assumption in the interest of accuracy. For example, timber production commonly conflicts with surface mining much more severely than with shaft mining, and this was considered in preparing the map. The commonly conflicting pairs are shown below.

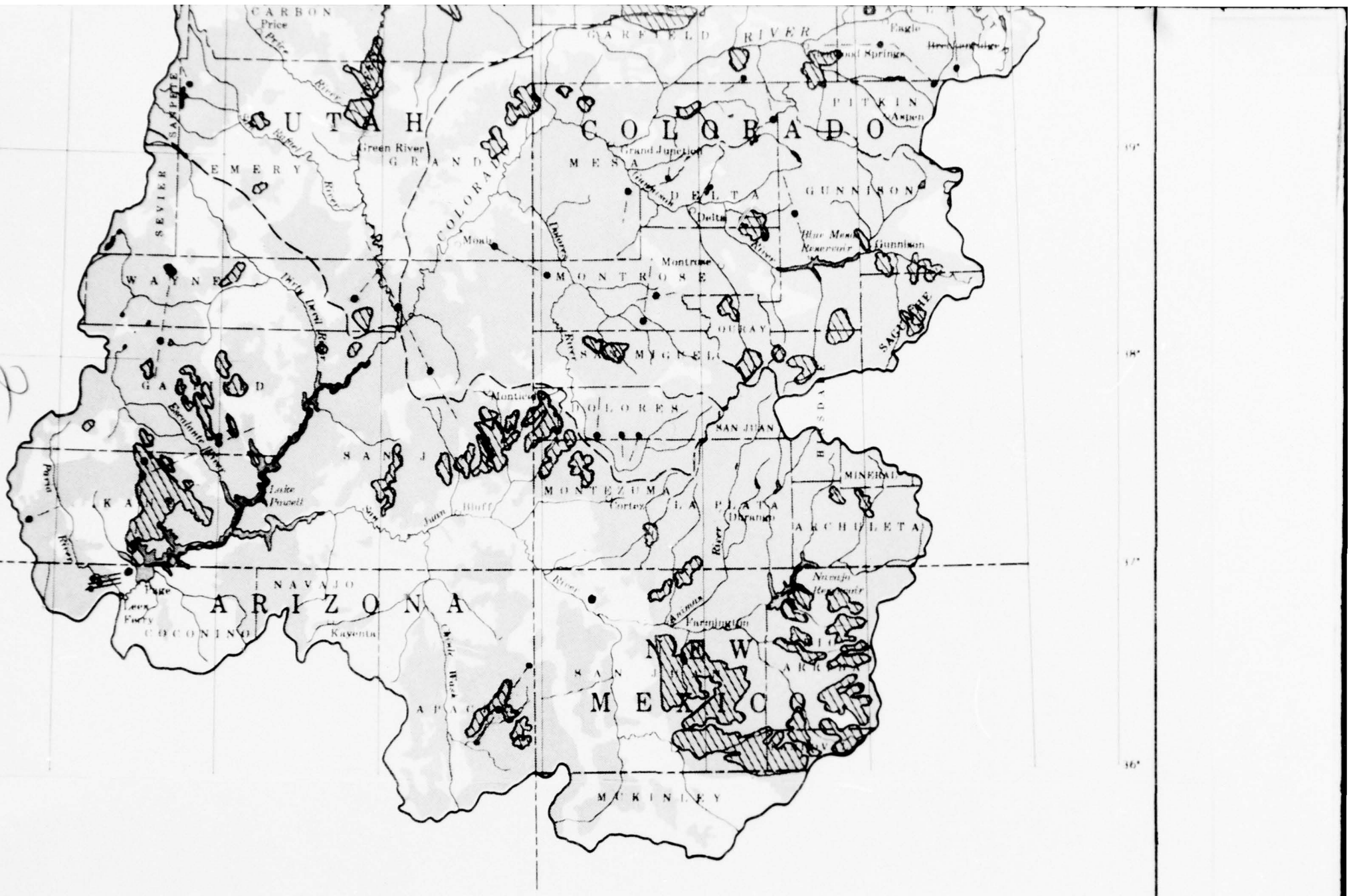
	Crop production	Cultural values	Electric power	Historic values	Mineral production	Natural values	Timber production	Wildlife habitat
Crop production		•		•		•	•	•
Cultural values	•		•		•		•	
Electric power		•		•		•	•	
Historic values	•		•		•		•	
Mineral production		•		•		•	•	•
Natural values	•		•		•		•	
Timber production	•	•	•	•	•	•		
Wildlife habitat	•				•			

Other values not available in a form suitable for analysis include transportation and communication facility needs, as well as recreation, military, urban, and similar intensive users of land.

Perhaps the most significant conclusion which can be reached as a result of this analysis is that no land use can occur without impact upon other present or potential uses. The fact that the Upper Colorado Region has the lowest population density of any region in the 48 conterminous states and is 65 percent in public ownership makes this conclusion even more significant.


TIMBER
CROPLAND
MINERALS
NATURAL
HISTORIC
CULTURAL
WILDLIFE
ELECTRIC
POWER


112°
111°
110°
109°
108°
107°
106°
43°
42°
41°
40°
39°
IDAHO
WYOMING
SALT LAKE CITY
UTAH
COLORADO
UPPER COLORADO
LOWER COLORADO
ARIZONA
NEW MEXICO
PHOENIX
MEXICO
Pinedale
SUBLETTE
Fontenelle Reservoir
LINCOLN
WYOMING
Kemmerer
GREEN
SWEETWATER
Green River
Rock Springs
UINTA
CARBON
Flaming Gorge Reservoir
SUMMIT
DAGGETT
RIVER
MOFFAT
ROUTT
Steamboat Springs
Vernal
Yampa
Duchesne
WASATCH
DUCHESNE
River
Duchesne
UINTAH
White
River
RIO BLANCO
GRAND
CARBON
Price
Price
River
GARFIELD
RIVER
EAGLE
Eagle
Glenwood Springs
PITKIN
Aspen
SANPETE
UTAH
COLORADO
Green River
Grand Junction
EMERY
GRAND
MESA
N

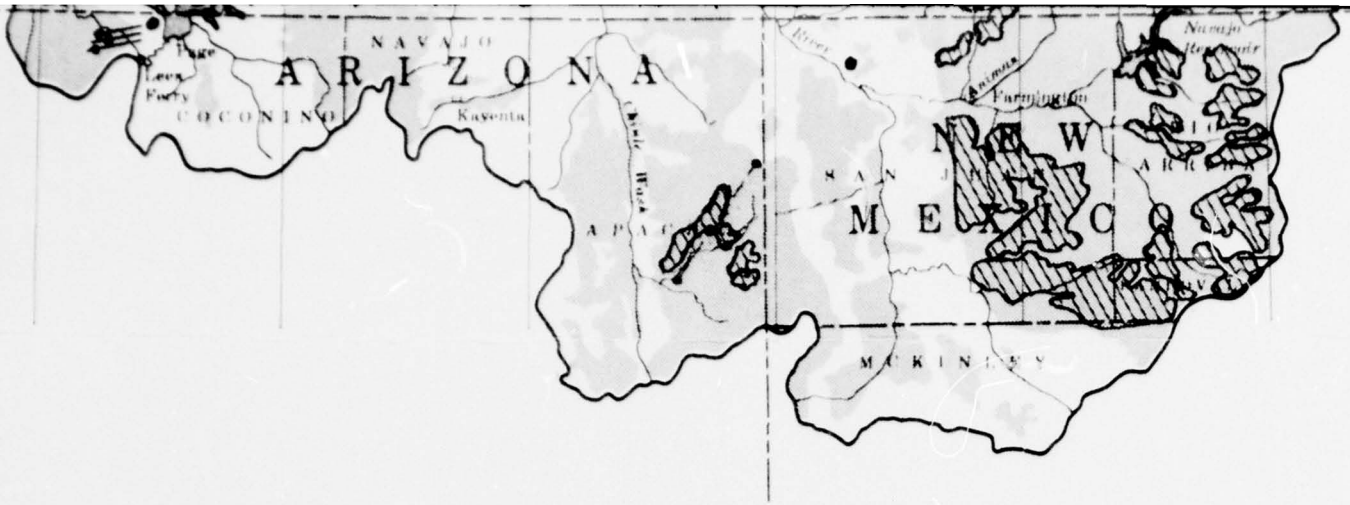


LEGEND

No preservation consideration identified

One or more preservation

UPPER COLORADO REGION
COMPREHENSIVE FRAMEWORK STUDY



LEGEND

- No preservation consideration identified
- One or more preservation consideration identified
- Possible conflicts among identified considerations
- Possible power corridor conflicts

Generalized preservation areas for the several resources are shown individually above. Precise areas for Minerals area preservation and for Electric Power corridors could not be developed; therefore these considerations were used only to determine potential conflicts. The small maps do indicate generally where significant values for these considerations exist.

UPPER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY

GENERALIZED PRESERVATION AREAS

1965

25 0 25 50 75 100 Miles

1970

Developed by Preservation Considerations Task Force, Upper Colorado Region Comprehensive Framework Studies

PART V

RESOURCE AVAILABILITY AND MEANS OF SATISFYING NEEDS

This section contains a summary description of the water, land, and other resources available in the region and identification of means to meet the needs of resource development.

Water Resources

The 52-year 1914-65 historical study period was selected to define the average annual virgin (or undepleted) flow for the subregions and region. General hydrologic conditions of this period are considered to be representative of conditions that can be expected to recur in the future. Also this period is the longest for which reliable records are generally available in the region. Historic flows were adjusted upward by adding past annual depletions in the years they occurred to obtain virgin flow figures; then the normalized use in 1965 was deducted to obtain the 1965 modified flow. Normalized evaporation for the main-stem reservoirs is also deducted from the total for the region. These data are shown in Table 32 and the figure following page 96.

Table 32 - Water Supply 1965, Upper Colorado Region
(1,000 acre-feet)

	Green River Subregion	Upper Main Stem Subregion	San Juan-Colorado Subregion	Upper Colorado Region
Virgin water supply (1914-65)	5,460	6,806	2,606	14,872
Level of depletions (1965)	993	1,397	418	2,808
Modified flow (1914-65)	4,467	5,409	2,188	12,064
Main-stem reservoir evaporation normalized (1965)				643
Outflow from region (1914-65)				11,421

The 11,421,000 acre-feet of outflow from the region under the 1965 level of development will be available under average conditions to meet commitments to the lower basin and meet future needs in the Upper Colorado Region. Main-stem storage capacity has been installed to provide long-term regulation to make deliveries to the lower basin and thus permit future development in the upper basin. Storage will be required in the region to regulate the seasonal and annual runoff variations to conform with the demand patterns.

PART V

RESOURCE AVAILABILITY AND MEANS OF SATISFYING NEEDS

Only a small amount of the ground water resources are presently developed, with 132,000 acre-feet being pumped in 1965. The maximum estimated recoverable ground water from the more permeable strata in the upper 100 feet is 17 million acre-feet. An additional 98 million acre-feet is not readily available because of poor permeability. Consideration of quality and economics prohibit large scale development of ground water.

Volume of surface water resources will not be materially affected by watershed treatment or management practices. Watershed restoration treatments may result in a small decrease in total streamflow in limited areas accompanied by a significant reduction in sediment yield and flooding. Extremes will be modified to a more constant flow. Water resource management in high elevation forests and alpine areas has evolved for increasing water yield and will more than balance losses in yield by watershed restoration in other areas. If weather modification methods can be perfected, increased water yield will be realized. There are sufficient water supplies to meet water needs under development of the regionally interpreted OBERS needs.

Land Resources

The region area totals 72.6 million acres, all of which are presently being used for one or more purposes. Most future developments will be guided by the multiple-use concept. Lands presently suitable and available for development are (1) grazing lands - 54.6 million acres; (2) commercial timber production - 9.4 million acres; (3) 1.6 million acres presently irrigated plus a part of the 7 million acres potentially irrigable lands without considering water development; (4) dry cropland - 603,000 acres; and (5) wilderness, primitive, outstanding natural historical and cultural, and scenic rivers where obtainable.

Relatively small acreages are required for projected development of (1) urban, industrial, transportation, and utilities, (2) developed recreation, fish and wildlife, (3) developed minerals, and (4) reservoir sites. About 41 million acres need to be managed under the multiple-use concept as key habitat for wildlife. Nearly all lands are available for extensive use as undeveloped recreation and hunting areas.

Other Resources and Related Considerations

Agriculture

Irrigated Cropland

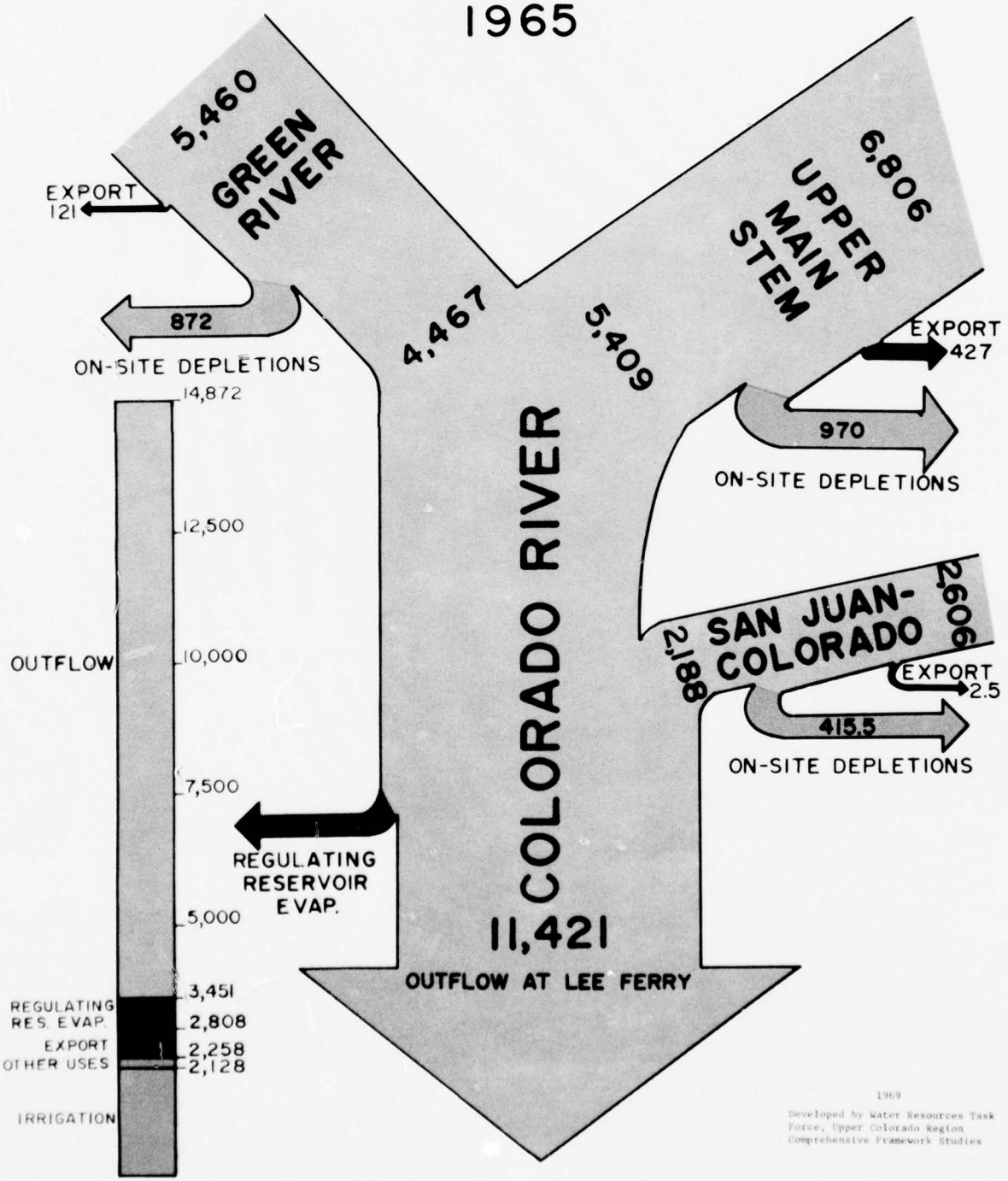
There is great potential for irrigation development of over 7 million acres of irrigable lands requiring full water supply. About 549,300 acres

UPPER COLORADO REGION

WATER SUPPLY (1914-1965),

ON-SITE DEPLETIONS & OUTFLOW FOR 1965

(In Thousands of Acre Feet)



1969

Developed by Water Resources Task Force, Upper Colorado Region Comprehensive Framework Studies

of the 1,621,500 acres of presently irrigated land are in need of supplemental water. The complex physiography and geology are principal factors governing the pattern of occurrence of the potentially irrigable lands. Distribution of the potentially irrigable land is shown on Table 33 and on the three maps following page 98. Irrigated cropland yield increases expected with adequate water supply and good cultural management are shown in Table 34.

Means for increasing production on presently irrigated lands include: providing supplemental water; installing drainage systems; improving irrigation systems to conserve water; utilizing ground water; adopting cultural management practices including use of improved crop varieties, land leveling and smoothing, efficient use of water, and fertilization.

Means for development of new irrigated lands include; providing full water supply; installing on-farm irrigation systems; providing drainage where needed for sustained production; adopting cultural management practices for efficient use of water and land.

Dry Cropland

Most suitable areas have been dryfarmed and the present 603,000 acres will continue to be dryfarmed except those converted to other uses.

Lands suitable for dryland farming are those lands that will produce profitable crops with natural rainfall and have soils that are moderately deep to deep with a combination of structure and texture favorable for absorbing and holding moisture. Summer fallow can be used to increase the amount of moisture available for crop production.

Means for increasing production on dry cropland include improving cultural management practices such as use of improved varieties, conserving soil moisture, maintaining soil fertility, and reducing water and wind erosion.

Livestock Grazing

In 1965 about 60.4 million acres were utilized for grazing but reduction to 53.4 million acres by 2020 is expected due to retirement of unsuitable land and conversion to other uses.

Essentially all increases in forage productivity must come as a result of increasing production on the remaining land. Production rates vary from less than one acre per animal unit month (AUM amount of feed or forage for one mature cow and calf or their equivalent for one month) to 50 acres per AUM. Forage production could be raised significantly on the majority of the rangeland as indicated in the tabulation.

Table 33 - Potentially irrigable land, Upper Colorado Region (thousands of acres)

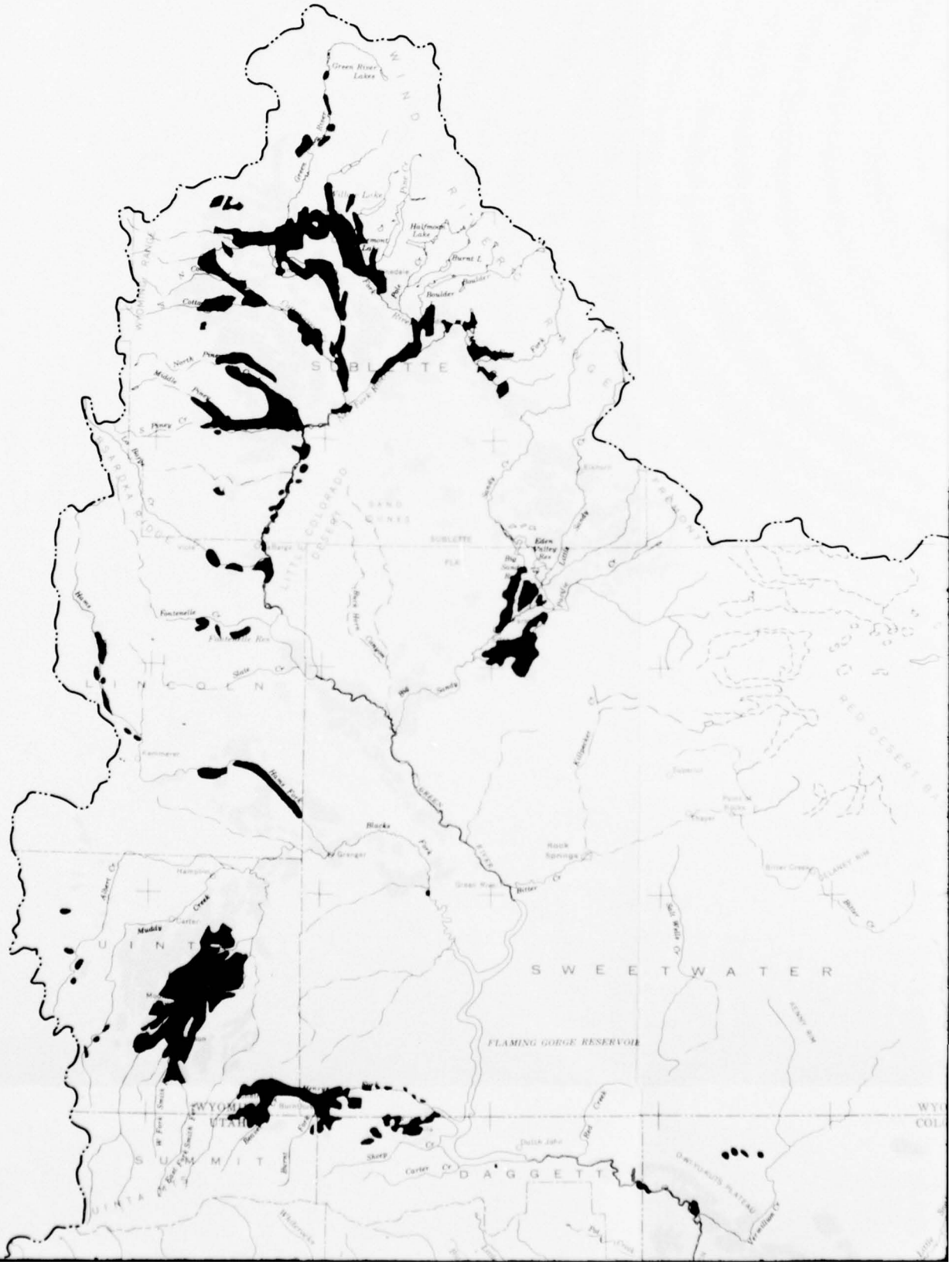
Hydrologic subregion and State	Class 1	Class 2	Class 3	Class 4	Total	Nonirrigable Class 6
Green River						
Wyoming	70.1	282.8	176.8	175.9	705.6	12,348.1
Utah	50.8	237.7	158.4	82.9	529.8	10,070.2
Colorado	46.3	392.4	260.8	177.2	876.7	5,758.5
Subtotal	167.2	912.9	596.0	436.0	2,112.1	28,176.8
Upper Main Stem						
Colorado	47.0	400.7	320.8	174.2	942.7	12,575.3
Utah	11.4	102.2	56.7	56.7	227.0	2,337.1
Subtotal	58.4	502.9	377.5	230.9	1,169.7	14,912.4
San Juan-Colorado						
Arizona	40.6	221.4	251.0	148.6	661.6	3,749.0
Colorado	12.3	115.7	75.3	42.1	245.4	3,269.1
New Mexico	70.3	773.8	1,034.8	589.7	2,468.6	3,696.2
Utah	26.4	174.2	140.5	60.1	401.2	9,749.7
Subtotal	149.6	1,285.1	1,501.6	840.5	3,776.8	20,464.0
Region						
Wyoming	70.1	282.8	176.8	175.9	705.6	12,348.1
Utah	88.6	514.1	355.6	199.7	1,158.0	22,157.0
Colorado	105.6	908.8	656.9	393.5	2,064.8	21,602.9
Arizona	40.6	221.4	251.0	148.6	661.6	3,749.0
New Mexico	70.3	773.8	1,034.8	589.7	2,468.6	3,696.2
Total	375.2	2,700.9	2,475.1	1,507.4	7,058.6	63,553.2

Class 1 lands are suitable for continued high yields of climatically adapted crops under sustained irrigation with minimum costs of development. Class 2 lands are moderately productive or require moderate costs for development and management because of slight to moderate limitations in land characteristics. Class 3 lands have restricted productivity for most crops or they require relatively high costs for development and management because of moderate to severe limitations in land characteristics. Class 4 lands have restricted crop adaptability because of severe limitations in one or more land characteristics.

UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

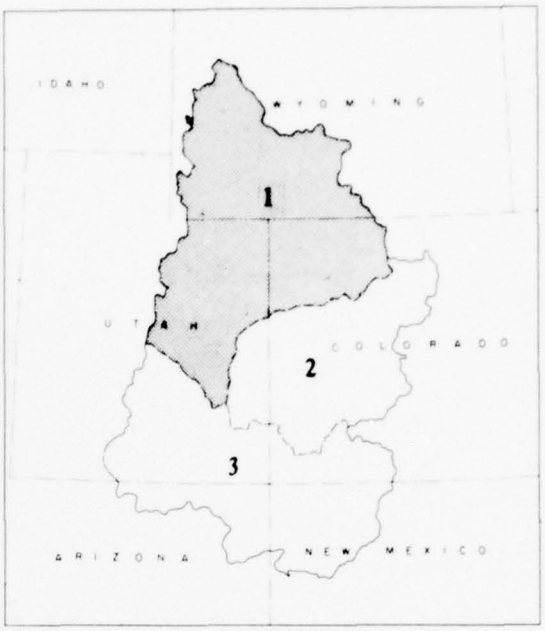
GREEN RIVER SUBREGION



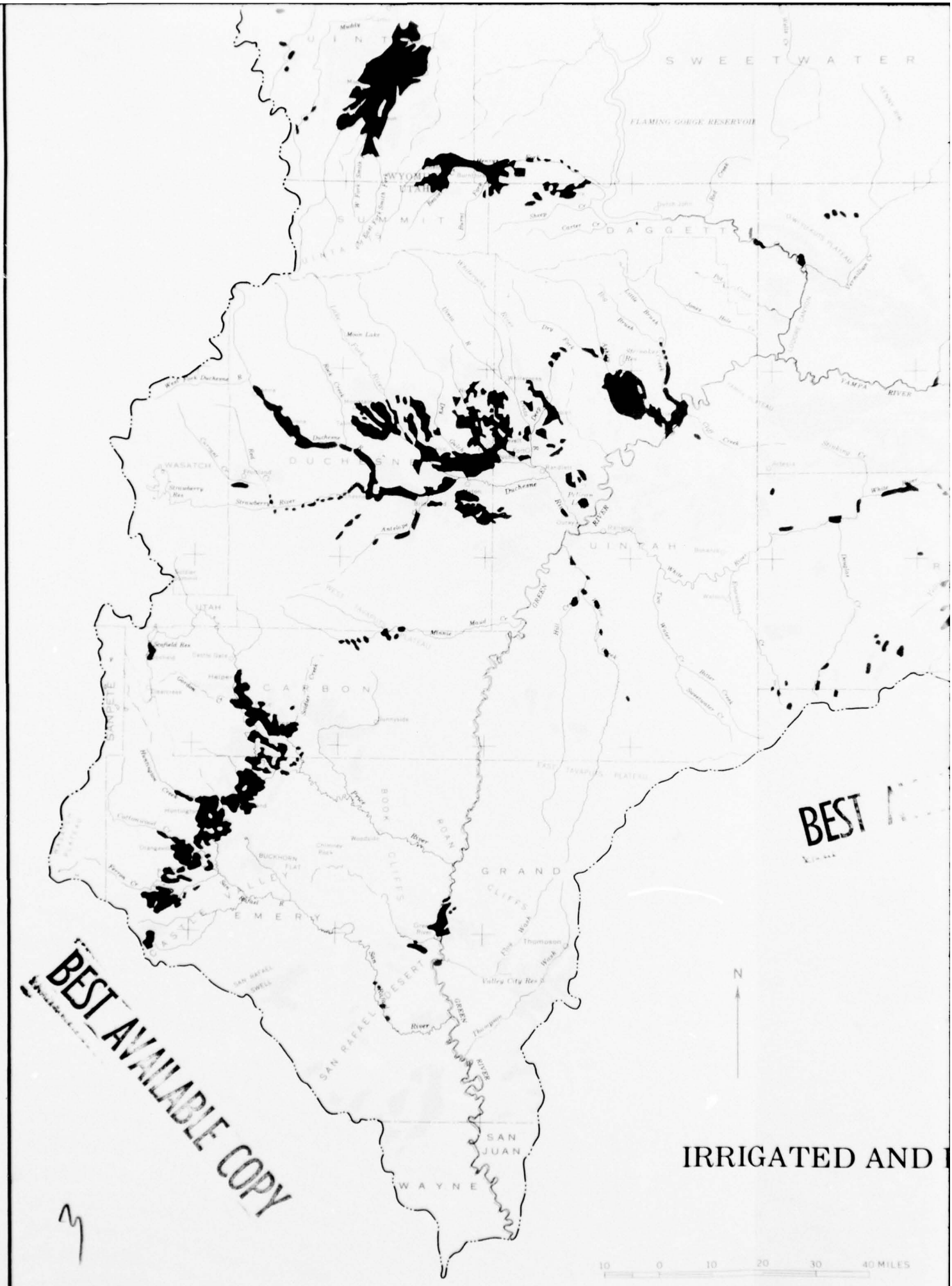
UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

GREEN RIVER SUBREGION



INDEX MAP



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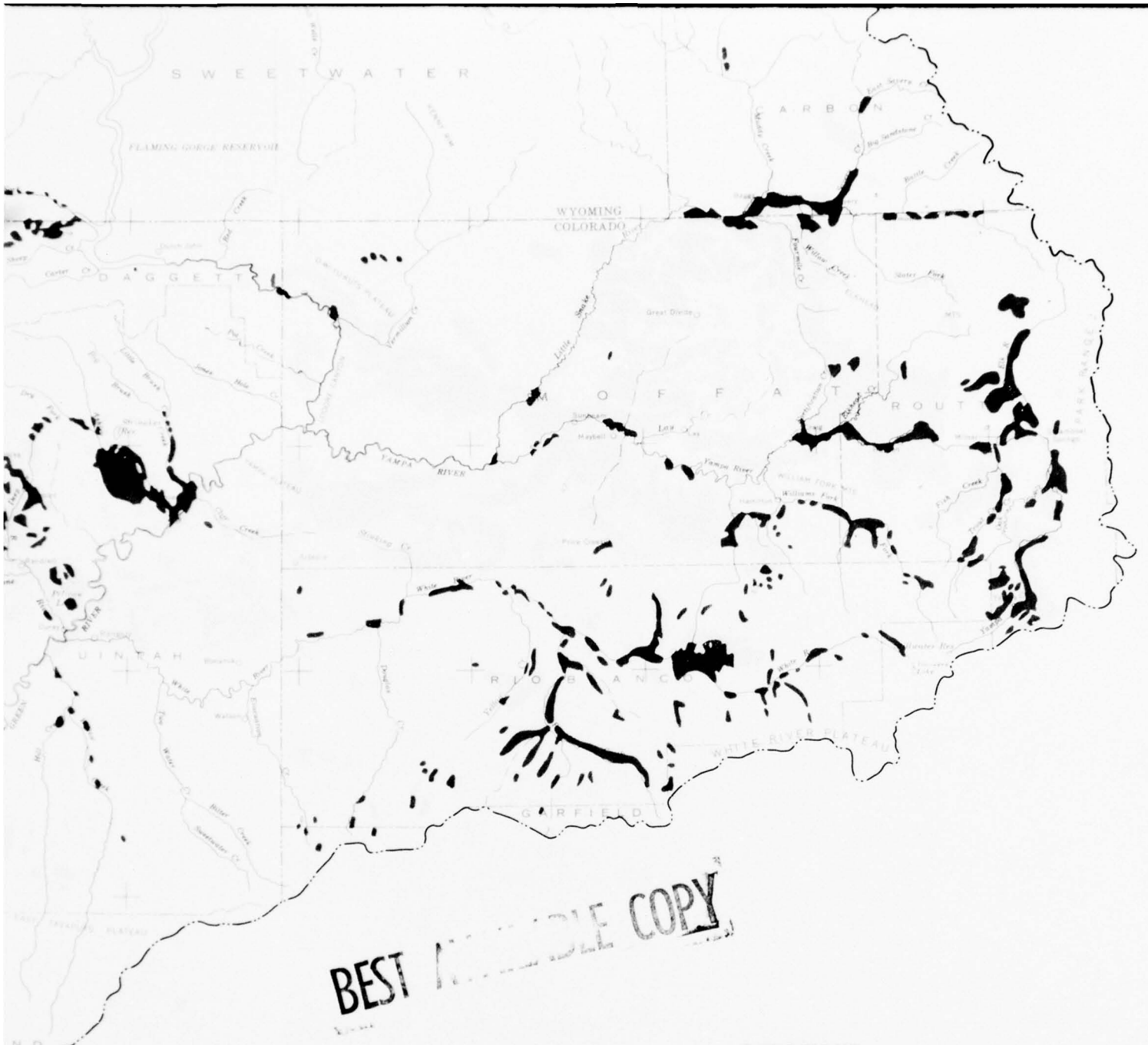
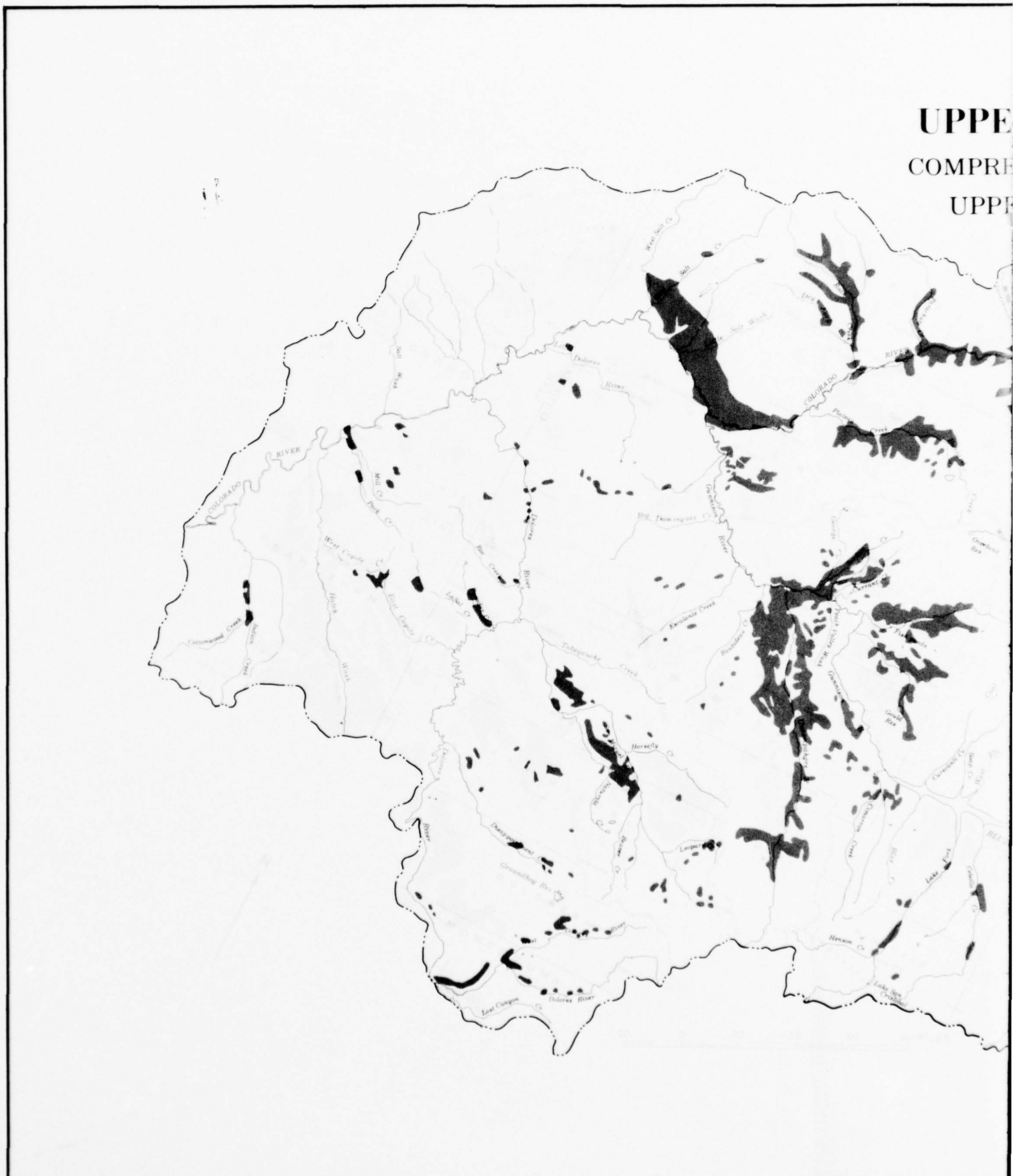


LEGEND

IRRIGATED LAND (1965)

POTENTIALLY IRRIGABLE LAND

IRRIGATED AND POTENTIALLY IRRIGABLE LAND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COLORADO RIVER
Salt Wash
Mill Cr.
Dolores River
Big Dominguez Cr.
Gunnison River
Escalante Creek
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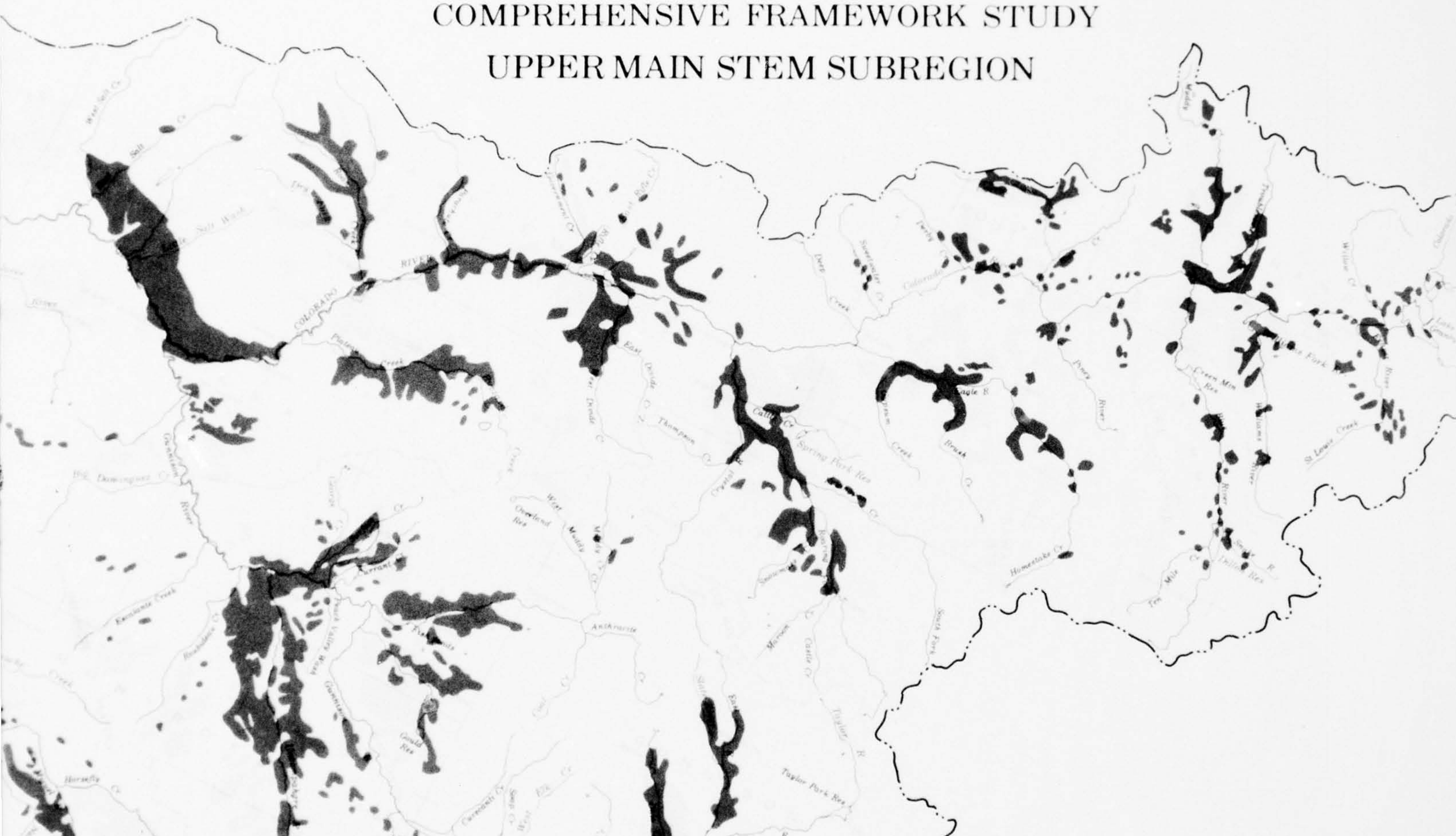
Horsefly Cr.
West Coyote Cr.
East Coyote Cr.
Cottonwood Creek
Indian Creek
Hatch Wash
La Sal Cr.
Roc Creek
Groundhog Res.
Lost Canyon Cr.
Dolores River
Henson Cr.
Lake San Cristobal
Lake Fork
Cimarron Creek
Cerro Cr.
Blue Cr.
Plateau Creek
Dry Fork
West Salt Cr.
Salt Cr.

UPPER COLORADO REGION

COMPREHENSIVE FRAMEWORK STUDY

UPPER MAIN STEM SUBREGION



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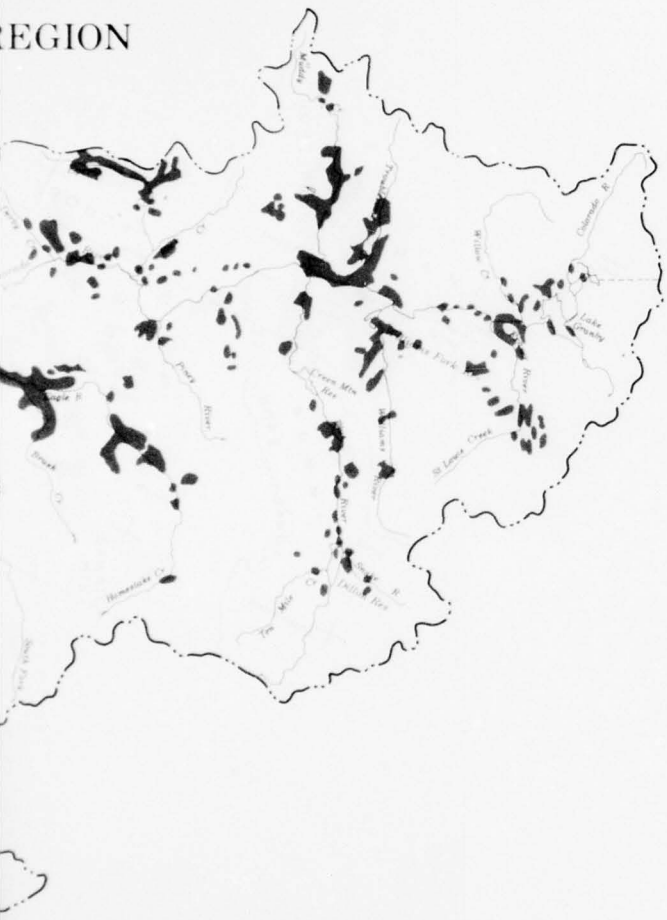

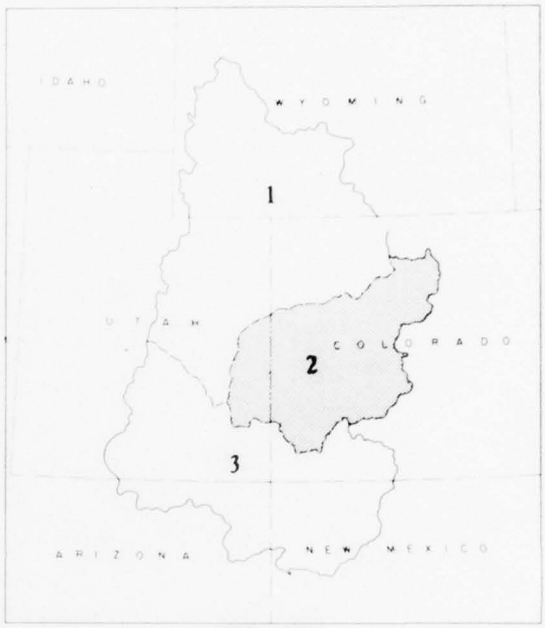

INDEX MAP

LEGEND

IRRIGATED LAND (1965)

POTENTIALLY IRRIGABLE LAND

IRRIGATED AND POTENTIALLY IRRIGABLE LAND

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UPPER COLORADO RE

COMPREHENSIVE FRAMEWORK

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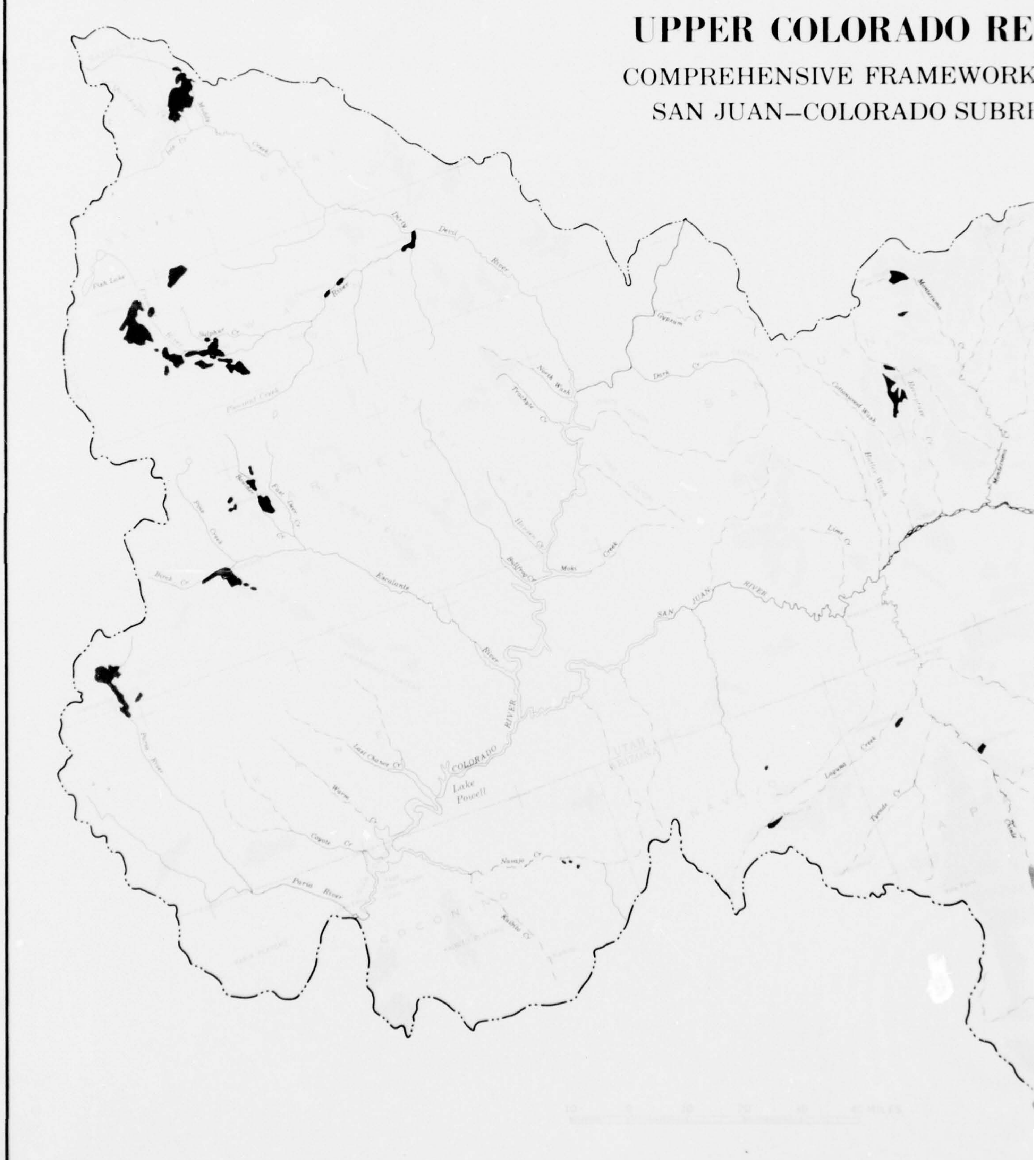
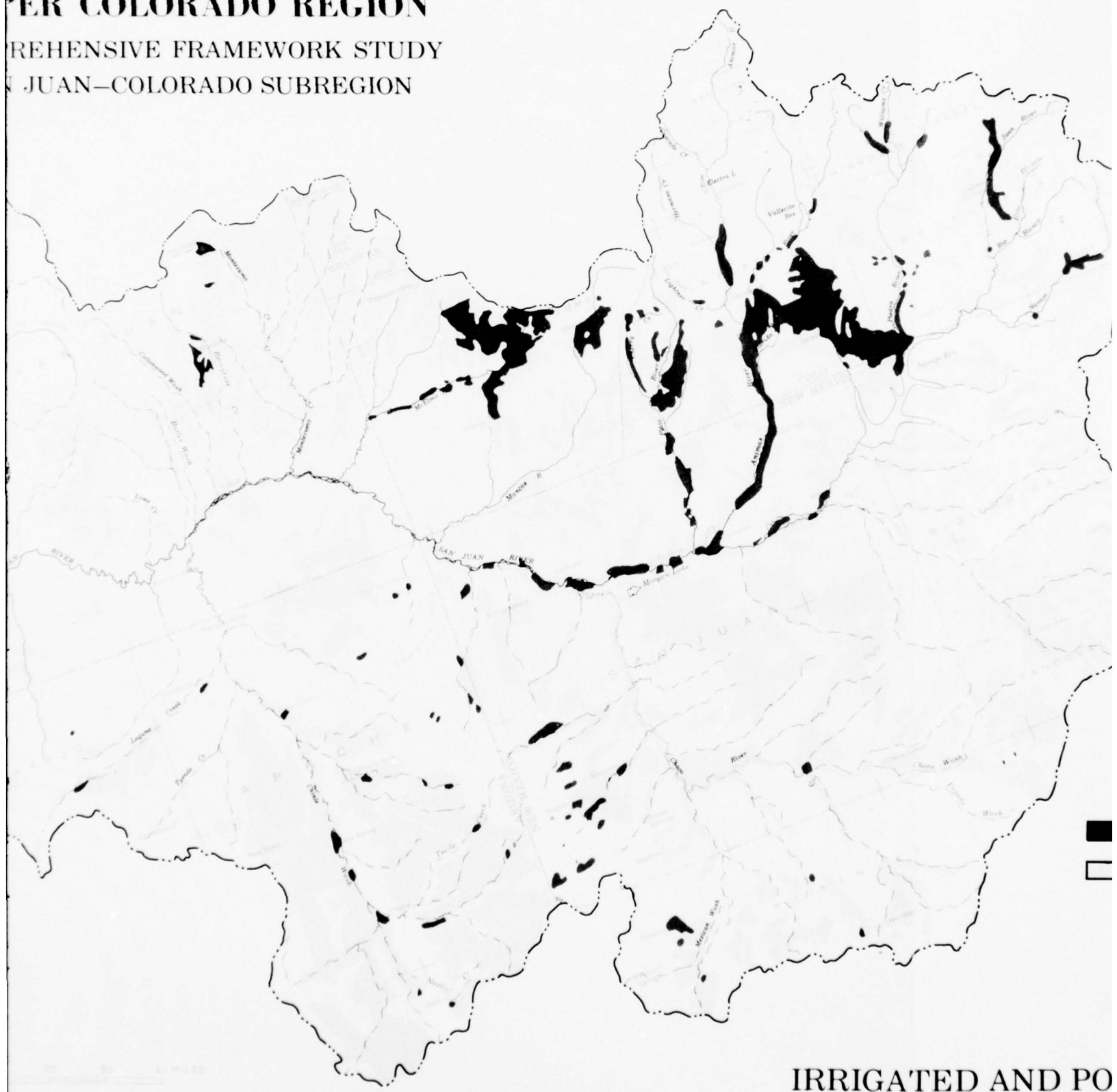


PER COLORADO REGION

REHENSIVE FRAMEWORK STUDY

JUAN–COLORADO SUBREGION



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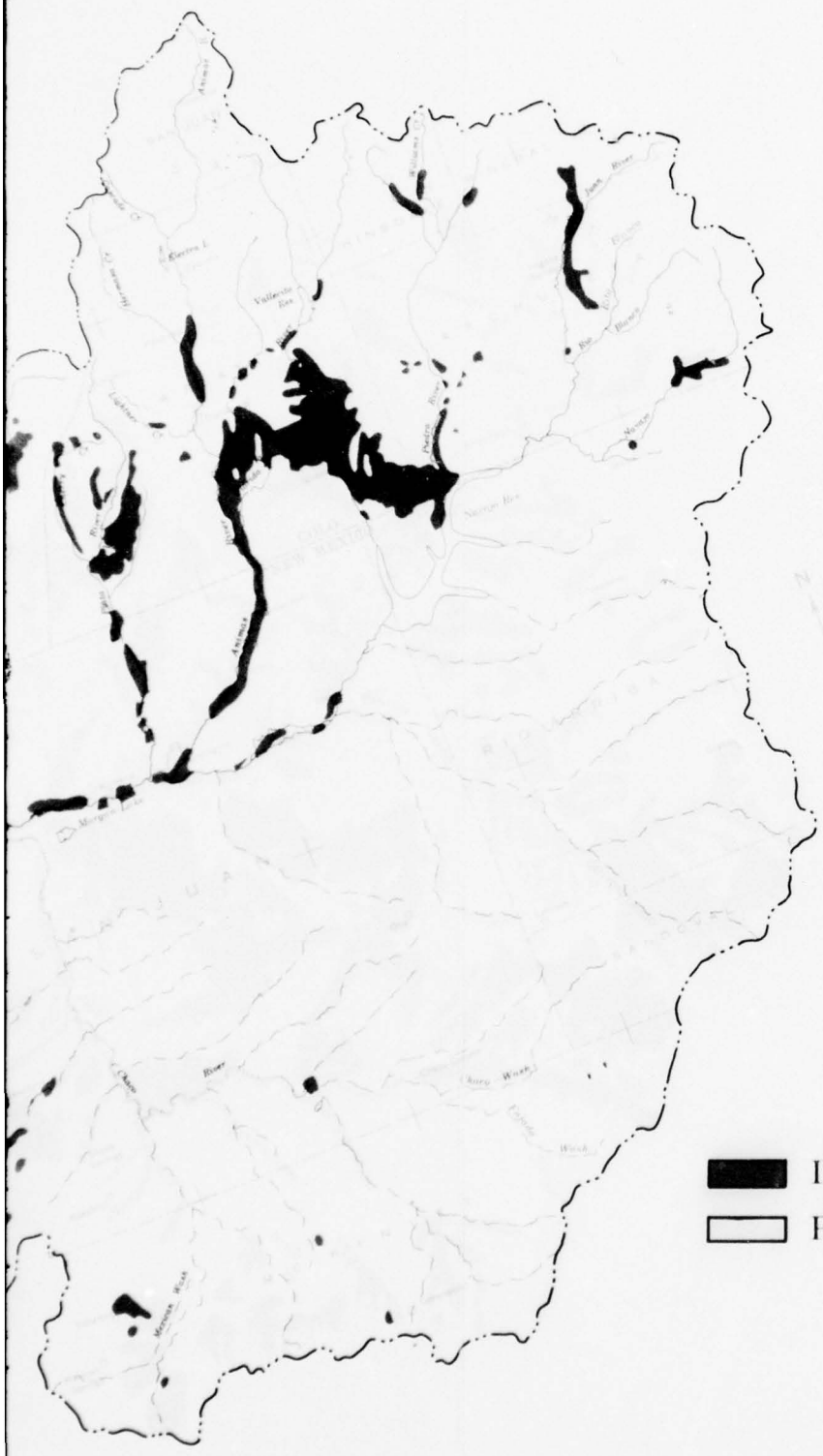
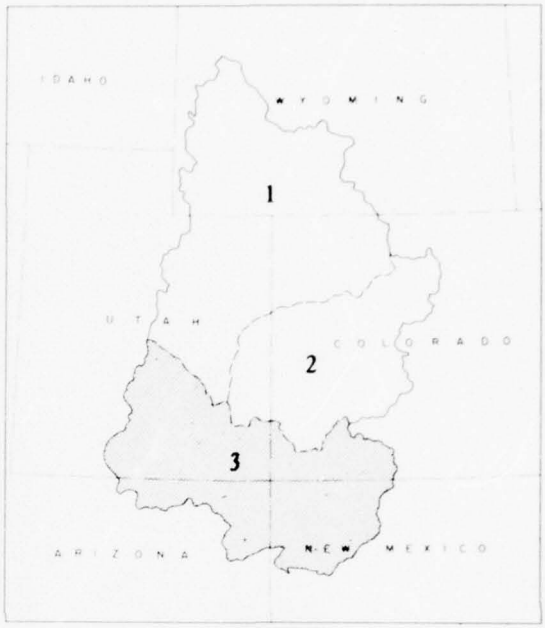




INDEX MAP

LEGEND

IRRIGATED LAND (1965)

POTENTIALLY IRRIGABLE LAND

IRRIGATED AND POTENTIALLY IRRIGABLE LAND

3

Table 34 - Estimated irrigated cropland yield increases, Upper Colorado Region (Yields per acre)

Crop	Units	1965	2020	Increase
Alfalfa hay	Tons	2.6	4.1	1.5
Improved hay	Tons	1.3	2.4	1.1
Native hay	Ton	0.75	1.0	0.25
Pasture	AUM	2.0	4.1	2.1
Corn silage	Ton	13.0	22.0	9.0
Oats	Bu.	50.0	73.0	23.0
Wheat	Bu.	31.0	60.0	29.0
Barley	Bu.	50.0	73.0	23.0
Corn grain	Bu.	70.0	112.0	42.0
Orchard	Ton	4.4	9.9	5.5
Sugar beets	Ton	15.0	25.0	10.0
Dry beans	cwt.	18.0	20.0	2.0
Truck crops	cwt.	75.0	159.0	84.0
Potatoes	cwt.	234.0	320.0	86.0

Animal unit month--grazing production potential

Ownership category	1965 production (1,000)	Potential production (1,000)	Increase (1,000)	Percent increase
Federal	3,292	4,581	1,289	39
Indian	745	1,788	1,043	140
State and private	1,900	2,956	1,056	56
Total	5,937	9,325	3,388	57

Means for obtaining the potential grazing production involves the following programs: improved grazing management systems; revegetation of depleted lands; brush and weed control; fencing; stock water development; protection of watersheds from erosion, flood, and sediment damage.

Investments in grazing management systems are the most promising solution to secure increases in forage output and maintain ecological stability of the watershed. These systems are sequences of livestock grazing by area designed to fit the timing and intensity of harvest to the growth habits of the vegetation. They may be employed for combinations of stock and on both native and introduced vegetation. These systems operate by manipulating the vigor, cover and composition of the vegetation, together with the stocking rate, season of grazing, distribution, and frequency of grazing of the livestock. Rest-rotation systems afford the manager the opportunity to produce the maximum amount of vegetation and to graze (harvest) it at or near the peak of its nutritive value. This is especially important since nutritive value of forage varies considerably during the life of a plant.

Timber Resources

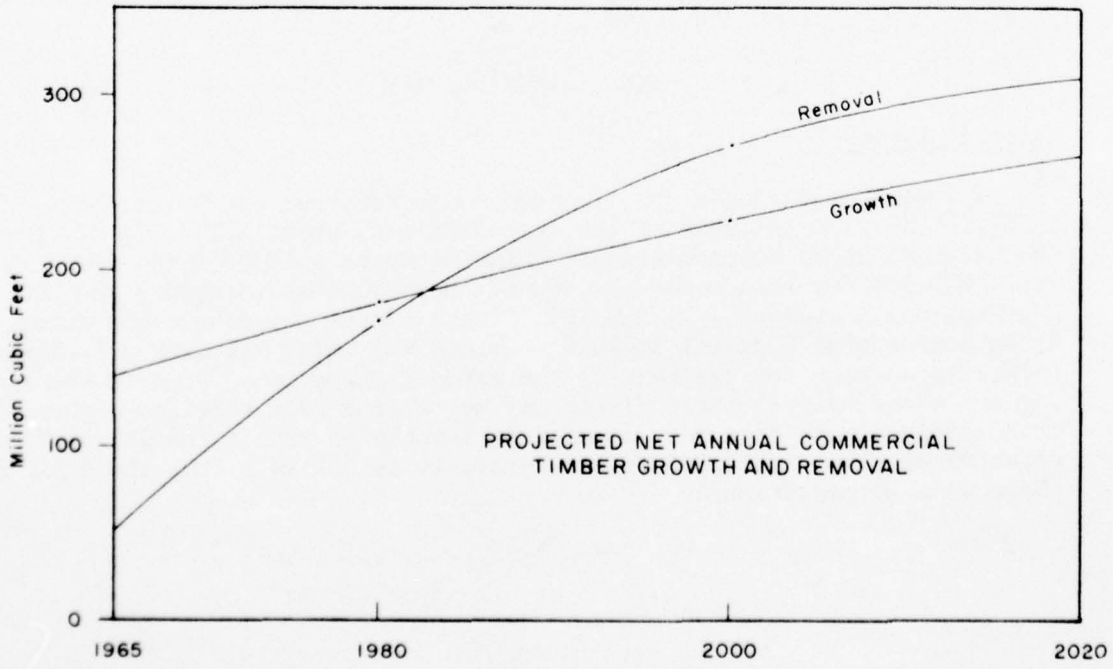
There are 9.4 million acres of forest lands which are presently (1965) suitable and available for commercial timber harvest. An additional 900,000 acres of commercial forest land have been reserved from production. As indicated by the tabulation on the following page, the preponderance (73 percent) of the growing stock volume is in sawtimber trees.

Future harvest of sawtimber-size trees will reduce the growing stock volume and decrease the inventory available to meet the projected needs. This makes it imperative that intensive timber management practices are accelerated to replace the volume of timber harvested and increase the capability to meet future needs.

	Total growing stock (million cubic feet)	Sawtimber trees (million cubic feet)	Poletimber trees (million cubic feet)	Sawtimber (million board feet)
Green River	4,299	3,078	1,221	16,358
Upper Main Stem	6,877	4,731	2,146	25,803
San Juan-Colorado	3,369	2,572	617	14,675
Total	14,545	10,561	3,984	56,836

Projections of net annual growth, removal (harvest), and inventory provide the basis for estimating timber supplies that will be available to meet anticipated demands. It is assumed that requirements for better access, improved management practices, and other considerations necessary for increasing sustained yield will be met during the projection period. However, certain more specific assumptions are necessary. One such set of assumptions indicates more plants to process increased volumes of veneer logs and pulpwood. In projecting growth and inventory, it is also assumed that as a result of increasing harvesting and intensified management, mortality losses will decrease and net growth rates will increase. Another assumption is that average tree size will be smaller in the future and as a result there will be less sawtimber volume in future stands.

The graph below portrays the projections of growth and regional needs (removal) for the various periods.



PART V

RESOURCE AVAILABILITY AND MEANS OF SATISFYING NEEDS

For the region as a whole, current (1965) annual removal of growing stock is about 38 percent of the current net annual growth. Annual growing stock removal is projected to equal growth by 1983, rising to 120 percent of growth by about 2012. Subsequently, although removal and growth both continue to rise, the difference becomes less and eventually (some time after the end of the projection period) they should be about equal.

Watershed management and flood control

Watershed Management

The means for satisfying the needs of upstream watershed protection and flood prevention on existing forest, rangeland, cultivated and pasture land, and urban areas to maintain and improve watershed conditions are as follows:

Land treatment measures
Water control structures
Resource management

Flood Control

The 13,000 acres of land needed for flood control programs is available for levees, channels and single purpose reservoirs. Other means for satisfying flood control needs include improved flood forecasting, watershed treatment, and flood plain management. Watershed treatment and flood plain management measures would occur on lands used for other purposes.

Industrial activity

Electric Power

Hydroelectric plants existing and under construction total about 1,323,867 KW with the bulk of the installations, about 1,248,000 KW, in the Colorado River Storage Project (Flaming Gorge - 108,000 KW; Glen Canyon - 950,000 KW; Blue Mesa - 60,000 KW; Morrow Point in 1970 - 120,000 KW; Fontenelle in 1968 - 10,000 KW). These plants and others scheduled to be constructed (Crystal in 1976 - 28,000 KW) under the CRSP will likely remain in service for the bulk of the projection period. Some of the smaller and older hydroelectric plants may be retired from service. Other hydroelectric plants have been studied in the region with a total installed capacity of about 1,800,000 KW. However, it is unlikely that the bulk of these will be constructed.

PART V

RESOURCE AVAILABILITY AND MEANS OF SATISFYING NEEDS

Thermal-electric generation has received great impetus recently due to demands for large blocks of electrical energy for export to adjoining regions and the availability of very large coal resources. Many large companies are actively engaged in the investigation, development, and construction of major coal-fired thermal-electric plants in all states of the region.

Nuclear-fueled powerplants are now technically feasible but are not likely to be economically feasible in the Upper Colorado Region in the near future due to the competition from coal-fired plants.

Obtaining required cooling water for the planned installations is a problem. Because of the limited water resources, once-through cooling for dissipation of waste heat is not practical for general use. Use of cooling towers, cooling ponds, or some combination thereof is expected; dry-type cooling towers are a possibility.

Mineral Resources

Minerals produced in significant quantities during the 1947-65 interval generally are available as reserves or resources in volumes sufficient to meet all foreseeable normal demands through 2020 (Table 35).

Total crude oil resources are about 6.7 billion barrels, of which about 0.8 billion barrels are reserve and about 5.9 billion barrels are predicted additional resource. Of the total, about 80 percent is in the Green River Subregion and 15 percent is in the San Juan-Colorado Subregion.

Total natural gas resources are 103 trillion cubic feet, of which 10 trillion cubic feet are reserve; about 85 percent is in the Green River Subregion and 12 percent is in the San Juan-Colorado Subregion.

The region is underlain by about 141 billion tons of coal distributed through all three subregions with about 55 percent located in the Green River Subregion. About one-half the resource is considered recoverable (Table 36).

The oil shale deposits of the region comprise the largest undeveloped energy resource of the United States. The rocks of the Green River formation, portions of which will yield "shale oil" through destructive distillation, underlay about 25,000 square miles (16 million acres) of land in the three-state region of Colorado, Utah, and Wyoming.

Approximately 11 million acres of land are underlain by oil shale of potential value for commercial development in the immediate future. These

Table 35 - Principal mineral resources, Upper Colorado Region

Resource	Quantity	Location and Remarks
Uranium in sandstone	127,000 tons	Mostly San Juan-Colorado
Uranium in phosphate rock	175,000 tons	Green River, very low grade
Vanadium	240,000 tons	Exploitable within uranium deposits
Thorite	3,900 tons	Upper Main Stem
Helium	41 billion cu. ft.	2/3 Green River, 1/3 San Juan-Colorado
Gilsonite	36 million tons	Green River
Bitumen	15 million barrels	60 percent Green River; 40 percent San Juan-Colorado
Lead	1.5 million tons	Upper Main Stem and San Juan-Colorado
Zinc	2.5 million tons	
Copper	0.25 million tons	Over ½ in Upper Main Stem. Most of remainder in San Juan-Colorado
Silver	555 million ounces	
Placer gold	2 million ounces	
Iron ore	5 million tons	65 percent iron, Upper Main Stem
Molybdenum	8 million tons	Mostly Upper Main Stem, tungsten as byproduct.
Phosphate rock	5,850 million tons	Mostly Green River
Potash	260 million tons	Minable by conventional methods
Pyrite	Multi-million ton deposits	Dolores County, Colorado 50 percent sulfur
Trona	67 billion tons	Source of natural sodium carbonate
Sand and gravel		Widely distributed throughout the region
Crude oil	6.7 billion barrels	Mostly in Green River
Natural gas	103 trillion cu. ft.	Mostly in Green River
Coal	141 billion tons	Widely distributed
Oil shale	2 trillion barrels	8,000 square miles of land in Colorado, Wyoming, and Utah
Rock asphalt	15 billion barrels	Primarily in Utah

Table 36 - Coal resources, Upper Colorado Region

Subregion, state, and county	Type of coal	Quantity (million short tons) Measured 1/	Indicated 1/	Inferred 1/
		Green River		
Wyoming	Bituminous	2,050	6,379	4,647
	Subbituminous	229	4,361	2,123
Colorado	Bituminous	9,650	2/	23,186
	Subbituminous	2,020	2/	3,691
Utah	Bituminous	4,289	143	13,588
Green River	Bituminous	15,989	6,522	41,421
	Subbituminous	2,249	4,361	5,814
		Upper Main Stem		
Colorado	Bituminous	2,959	2/	4,702
	Subbituminous	863	2/	1,185
	Anthracite	41	2/	50
Utah	Bituminous	134	2/	2,000
Upper Main Stem	Anthracite	41	2/	50
	Bituminous	3,093	2/	6,702
	Subbituminous	863	2/	1,185
		San Juan-Colorado		
Arizona			Not Inventoried	
Colorado	Bituminous	502	2/	9,144
New Mexico	Bituminous	49	67	3,969
	Subbituminous	515	1,175	26,724
Utah	Bituminous			10,500
San Juan-Colorado	Bituminous	551	67	23,613
	Subbituminous	515	1,175	26,724
Region totals	Anthracite	41	2/	50
	Bituminous	19,633	6,589	71,736
	Subbituminous	3,627	5,536	33,723

Source: U.S. Geological Survey

1/ Measured resource implies a fairly precise estimate, indicated resource represents an intermediate degree of estimation, and inferred resource largely is based upon geologic inference. All estimates are traditionally conservative.

2/ Indicated and measured undifferentiated.

deposits include high-grade shales (more than 25 gallons per ton and at least 10 feet thick) capable of yielding 600 billion barrels and additional 1,200 billion barrels are potentially available from lower grade deposits yielding 15 to 25 gallons of oil per ton.

Extensive saline resources include a wide variety of saline minerals, the most important being carnallite, dawsonite, gypsum, halite, nahcolite, sylvite and trona; in addition subsurface occurrences of high-density brines contain high concentrations of calcium, magnesium and potassium.

Sand and gravel and cement raw materials are widely distributed in the region. Generally, adequate supplies of these materials can be developed from nearby sources; they are present in such huge quantities that no numerical estimate is justified.

The means of satisfying the needs and demands for development of mineral resources are through private capital investment in production facilities. Essentially only mining and basic processing now exist within the region. When economic justification and technical capability materialize, an expansion of local milling and processing may be expected that will increase mineral availability for national needs.

Recreation - fish and wildlife

Recreation

Although the region generally contains land and water resources in sufficient quantity and quality to meet most projected resident recreation needs, there are several very real restraints that may result in the fulfillment of only a portion of needs of nonresidents. Of primary importance in this regard is the fact that in order to meet these needs, many lands that now are in a multiple-use status, that now include low intensity recreation use, would have to be converted either to primary use for recreation or at least to greater intensity of recreation use. Before such changes were made in an attempt to meet all needs, special consideration should be given to preventing deterioration of the resource base or of the recreation experience as a result of recreation over use. In this regard, the unique, high-quality character of the natural resources that remain in this region should be kept in mind before decisions are made to lessen these qualtities to accommodate intensive use.

Of the projected water needs, it is estimated that about 64 percent, or 214,000 acres will be accommodated by 2020. When put in perspective by the dominant influence of nonresident recreationists and generally dry climate, fulfillment of no more than this amount of the water need is not necessarily bad. This is primarily an arid to semi-arid region and most

of the water based recreation demand which previously did not exist, has been generated by construction of large reservoirs. Also, body contact water activities are not common at elevations above about 7,000 feet. Therefore, part of the unmet water needs will be for water skiing and swimming and it may be more realistic to meet these needs elsewhere or by substitution of other activities.

Restraints that may be of even more importance than the availability of the natural resource base are those associated with costs of acquisition of land for the non-Federal sector, development of recreation and service facilities, and operation and maintenance. Also, legal problems associated with cost sharing and with access upon or across private lands might affect recreation needs satisfaction. With these considerations, it is through a combination of development, acquisition, and recreation management programs of various agencies and interest concerned that land and water areas and facilities will be made available for the diverse recreation needs.

Fish and Wildlife

In general there are ample waters available to satisfy fishing demand through 2020, assuming that future water development planning will recognize needs for releases to preserve stream habitat and for minimum fish conservation pools in new reservoirs. The fish and wildlife programs will further improve availability by placing fisheries where there are local shortages or convenient opportunities.

The only exception is that part of the San Juan-Colorado Subregion in Arizona and New Mexico where shortages will occur after 1980. The needs for water for fishing were estimated on the basis of fulfillment with new fishing impoundments. However, since much of the demand will be by Navajo Indians, it is possible for them to find fishing on other-purpose reservoirs anywhere on the Reservation. A few potential developments in the Utah portion of the Navajo Reservation have been proposed. If such reservoirs should be built, it would be possible to erase the deficiency for Arizona, and also accommodate a small part of the unsatisfied demand assigned to New Mexico. The only other possibility for water for fisheries in Arizona and New Mexico would be recommitment of undeveloped water now dedicated to other uses or purchase or transfer of water rights.

The situation is similar with respect to waterfowl hunting. Water needs for waterfowl hunting areas in Arizona and New Mexico indicate shortages before 1980. The only apparent means to acquire the amounts needed would mean rededication to waterfowl of water committed for other uses.

PART V

RESOURCE AVAILABILITY AND MEANS OF SATISFYING NEEDS

Lands for fish and wildlife, fishing impoundments, waterfowl areas, and big-game areas can be purchased from ranches or withdrawn from publicly owned lands. It may be assumed that such lands will continue to be available.

Availability for wildlife of the key habitat areas is dependent on how they are developed and managed. Practices that would depreciate habitat include changes in land use in the higher deer and elk winter ranges, major reservoir development in river valleys that contain good moose or waterfowl habitat, the removal of sagebrush in sage grouse and antelope ranges, and phreatophyte control in moose wintering areas along watercourses. However, if wildlife conservation is given adequate recognition as a prominent objective of development and management in the key habitat areas, wildlife habitat will remain available, and its capacity may possibly be improved.

Fishing, hunting, and fish and wildlife resources will hopefully be maintained to meet future demands by an extension of present programs. For fish management such programs are briefly described:

1. Provision for minimum pools for fish conservation in multiple-purpose reservoirs.

2. Provision for minimum downstream releases from new reservoirs for preservation or enhancement of stream fish habitat.

3. Construction of fishing impoundments to provide fishing opportunities in localities where little or none now exists.

4. Acquisition of water rights to provide minimum pools in the existing reservoirs that can now be emptied.

5. Road construction for access to fishing waters.

6. Construction of public-use facilities primarily for fishermen.

7. Increased hatchery production.

8. Stream, lake, and reservoir habitat improvement.

For hunting and for wildlife these programs will continue:

9. Acquisition or withdrawal of lands for primary use as big-game management, especially for the improvement of critical winter habitat.

10. Acquisition or withdrawal of lands for primary use as waterfowl areas.

11. Range plant control and replanting with plants of value for wildlife.

12. Construction of watering facilities for wildlife in arid areas.

13. Fencing to aid habitat management.

14. Management of multiple-use lands for optimum key habitat.

15. Road construction for hunter access.

16. Introduction of new wildlife species and restocking of former range.

Of the many programs listed, only numbers 3 and 10 will consume significant amounts of water allocable to fish and wildlife.

Water exports

The region is bounded on the north, east, and west by high mountain ranges whose in-basin slopes constitute the major water contributing areas of the region. In the adjacent areas, population expansion, agriculture, and industry have overshadowed similar in-basin developments. Thus there became a demand for transmountain diversions. Existing compacts and agreements give recognition to such exports. Additional export is limited by the availability of water and the desire of each state to export its remaining allotment or part thereof.

Physically speaking there are a number of opportunities for further expansion or new exports of water to areas adjacent to the region. The means of accomplishing this expansion involve additional in-basin storage reservoirs to compensate local uses and effect control of season runoff.

Water quality, pollution control, and health factors

The means for meeting water quality and environmental health objectives include:

1. Implementation of an effective Colorado River Basin salinity improvement program.

2. Establishment of a mine drainage pollution abatement program.

3. Expansion of State-Federal water quality standards to cover additional quality criteria and to include intrastate streams where this has not been done.

4. Modification of land and water resource management practices.

5. Study of the relationship of minimum streamflow to water quality as a means of meeting water quality requirements.

6. Development of environmental control programs at all levels of government to support present programs which protect the public from health hazards from air, water, and vector-borne diseases.

7. Expansion of comprehensive electric powerplant site planning to minimize adverse environmental effects.

Military

Suitable lands for military-related purposes will be available to meet future needs. Programs will be developed by the military as requirements are delineated by national policy.

PART VI

FRAMEWORK PLAN AND ALTERNATIVES

The basic purpose in formulating the framework plan is to provide a broad guide to outline development of water, land, and related resources to meet regionally interpreted OBERS and associated requirements to the year 2020. Development of the plan incorporates coordinated analysis for all water and related land use with consideration of constraints imposed by physiographic characteristics, the overall shortage of water, and the legal and institutional environments. Plans, goals, and needs of the states and other localized areas were also considered.

Water allotments, priority of use, and delivery commitments within the terms of the Colorado River Compact, the Mexican Water Treaty, and the Upper Colorado River Basin Compact set forth obligations which were considered. These factors, along with separate state water codes, imposed significant constraints.

This study gives cognizance to environmental assets for a pattern of future development which will preserve or enhance the esthetic and health-related attributes. The plan includes features which minimize adverse environment impacts and largely compensate for unavoidable effects. Identification of problems in this study should permit resolution of conflicts and allow timely and coordinated use of the resources in meeting future demands.

The comprehensive framework plan is based upon identified needs and requirements, using available resources to meet regionally interpreted OBERS projections through the year 2020. This plan is described and then is followed by a discussion of alternative plans that reflect emphasis on different uses for the available water supplies and resources. The alternative plans are identified as:

(1) States' alternative to the framework plan (6.545 million acre-foot level of development),

(2) States' alternative at the 8.16 million acre-foot level of development, and

(3) States' alternative for water supply physically available at site in the region (9.44 million acre-feet).

Consideration was initially given to formulation of a plan to meet the needs contained in the 1968 OBERS projections. Plans were not developed because of basic inconsistencies in the agricultural projections and a need to conform to planned and anticipated development in the minerals, timber, and power sectors.

It should be noted that these studies were made to demonstrate certain levels of water resource development and that these studies shall not prejudice the position of either the Upper or Lower Basin interests with respect to required deliveries at Lee Ferry pursuant to the Colorado River Compact. In particular, the depletions are site-located and do not necessarily reflect direct relationships to streamflow diminishment at Lee Ferry, Arizona.

Framework Plan

Purpose and summary

The framework plan broadly outlines development of the region's water and related land resources to meet the regionally interpreted OBERS projections with minimum adverse effects on the environment. Most project developments and structures have not been site-located. Further engineering, economic, and environmental analyses will be required in detailed planning for the individual segments. Estimates of costs and general adequacy of plans are discussed.

Water depletions will increase to 6.545 million acre-feet by 2020 while all of the region's land resources will receive continued and more intensive use. Population will approximately double from 366,000 in 1965 to 680,000 by 2020.

Local needs for municipal and industrial water supply (excluding power, minerals, and agriculture) will remain small when compared to the total water use. Future recreation, sport fishing, and hunting demand by residents and nonresidents will require a continuation and extension of present programs and management practices.

Projected total gross output for agricultural products to meet demands and needs would more than double for most subregions and sectors of production. Livestock and livestock products and food and field crops are the major sectors. Production on existing irrigated cropland would increase and 500,600 acres of additional irrigated land would be brought into production.

Output of timber products is projected to increase seven times to 340 million cubic feet due largely to demands from outside the basin.

Transmountain diversions from the region would triple to about 1.6 million acre-feet to meet a portion of the demands for municipal, industrial, and irrigation water in adjacent regions. Outflow to the Lower Colorado Region would continue as required by the Colorado River Compact.

The capacity of electric powerplants will be about 19 times as great by 2020 as in 1965. Local use plus reserve will require about 18 percent of the total generation.

Value of mineral production in the region is expected to increase from $543 million in 1965 to $2,014 million in 2020.

Elements of plan

Present Base (1965)

The agricultural base in the region is primarily a cow-calf and sheep enterprise utilizing 1.5 million acres of irrigated and dryland feed crops and 60 million acres of Federal and private grazing land. Also marketed are cash crops from 50,000 acres, such as fruit, sugar beets, Moravian malting barley, and vegetables. Dry beans and wheat are also grown as cash crops on 301,000 acres of both dry and irrigated farms. Presently 124,000 acres of irrigated land are idle and 185,000 acres of dry cropland are not cropped annually.

Industrial development in the basin represents a substantial part of local economic activity. Remote location, limited supply of labor, and unavailability of capital resources have effected growth. Petroleum, molybdenum, coal, uranium, and trona dominate present production and value in the mineral industry. Thermal-electric power generation utilizing local coal resources has an installed capacity of 1,335 megawatts. Timber products harvested in 1965 amounted to 53.0 million cubic feet, of which about half or 311 million board feet were sawtimber.

The region is part of one of America's outstanding recreation and tourist areas in a quality environment setting. Abundant fishing and hunting exist for both residents and nonresidents.

Main-stem storage development provides 33 million acre-feet of storage regulation to meet outflow requirements from the region and allow for regional development. These facilities include 1,300 megawatts of installed capacity for hydroelectric power and have a large potential for water-based recreation.

New Proposals

Agriculture.--Potential programs for increasing production of crops and livestock and livestock products include developing new irrigated land and increasing production on the present irrigated, dry cropland, and grazing lands.

Irrigated cropland development.--Irrigated cropland in the basin would increase from the present base of 1.6 million acres to 2.1 million acres. New irrigated land totaling 587,600 acres will be needed by 2020 to meet additional needs and replace 87,000 acres lost to urbanization and other uses. Production on present lands would be increased by structural, cultural, and management practices.

Participating projects of the Colorado River Storage Project authorized or funded for construction, in advance planning, or under preconstruction studies would develop water for 364,000 acres of new irrigated land and supplemental water for 253,000 acres. This includes 110,600 acres of new irrigated land in New Mexico for the Navajo Indians.

In addition, selected potential participating projects of the CRSP would bring into production 136,000 acres of new irrigated land and furnish supplemental water to 73,000 acres.

Non-Federal development would bring into production 87,000 acres of new irrigated land and furnish supplemental water to 95,000 acres presently being irrigated.

Ninety reservoirs with a storage capacity of 2.1 million acre-feet would be built for the primary purpose of supplying irrigation water. However, they will also be multipurpose.

An estimated 176,000 acres or 30 percent of the newly developed land will require on-farm and project-type drains. Development of new irrigated land requires installation of new canals and ditches, land leveling and smoothing, and water control structures.

Increased production on presently irrigated lands would be obtained by development of supplemental water for 421,000 acres, drainage of 437,000 acres, irrigation system improvement on 911,000 acres, increased water-use efficiency, and use of improved cultural management practices.

Dry cropland.--About 100,000 acres of the 603,000 acres of presently dry cropland would be transferred to other uses, primarily to irrigation. Improved cultural management practices applied to dry cropland would result in a small increase in yields. The programs for increasing production on these lands include: (1) use of improved plant varieties, (2) fertilization, (3) reduction of erosion by contour and cross-slope tillage, (4) constructing 100 miles of diversion ditches, (5) establishment of grass waterways covering 3,000 acres, (6) fall chiseling on 100,000 acres annually in areas of deep snow accumulation, and (7) limited tillage using stubble-mulch methods on 150,000 acres annually.

Grazing development.--Forage on range and forest land would be increased 1.3 million animal unit months of grazing. In spite of unsuitable lands being retired to other uses, overuse and abuse being curtailed, and demands of grazing land for other uses, total production will increase 20 percent. The program for obtaining the increased production includes management practices, land treatment, and installation of structures. (See Tables 37 and 38 listing these practices.)

Timber production.--In order to meet projected needs, the output of timber products must be increased to seven times the 1965

Table: 37.--Projected land management production programs, Federal land summary, Framework Plan, Upper Colorado Region

PRACTICE	1966 - 1980				1981 - 2000				2001 - 2020			
	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL
WOOD PRODUCTION												
Timber Management Systems 1/ Acres	2,334,000	3,532,000	1,708,000	7,574,000	2,327,000	3,522,000	1,704,000	7,553,000	2,322,000	3,514,000	1,699,000	7,535,000
Thinning, Pruning Acres	70,000	106,000	51,000	227,000	117,000	177,000	85,000	379,000	47,000	71,000	35,000	153,000
Planting, Seeding Acres	35,000	53,000	26,000	114,000	58,000	89,000	42,000	189,000	23,000	35,000	17,000	75,000
FORAGE PRODUCTION												
Grazing Management Systems 1/ Acres	16,996,000	6,855,000	7,124,000	30,975,000	16,996,000	6,855,000	7,124,000	30,975,000	16,996,000	6,855,000	7,124,000	30,975,000
Water Developments No.	2,864	3,602	1,395	7,861	3,993	4,672	1,453	10,118	1,128	287	445	1,860
Fences Miles	2,082	1,402	2,038	5,522	2,570	1,672	2,321	6,563	882	291	739	1,912
Plant Control Acres	40,130	149,400	34,033	223,563	40,130	149,400	34,033	223,563	8,000	30,000	3,400	41,400
Revegetation Acres	12,425	4,162	26,465	43,052	12,425	4,162	26,465	43,052	2,500	830	5,300	8,630

1/ Grazing and timber management systems acreages are not cumulative by time frames.

Table: 38.--Projected land management production program, private land summary, Framework Plan, Upper Colorado Region 1/

PRACTICE	1966 - 1980 Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	1981 - 2000 Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	2001 - 2020 Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL
FORAGE PRODUCTION												
Grazing Management Systems 2/ Acres	8,831,674	3,506,345	11,167,510	23,505,529	8,831,674	3,506,345	11,167,510	23,505,529	8,831,674	3,506,345	11,167,510	23,505,529
Water Developments No.	900	437	206	1,543	1,600	1,100	700	3,400	900	600	470	1,970
Fences Miles	800	600	100	1,500	1,100	1,100	180	2,380	800	600	200	1,600
Plant Control Acres	93,871	64,900	280,733	439,504	174,000	90,000	258,316	522,316	96,000	85,000	255,461	436,461
Revegetation Acres	39,400	17,000	175,310	231,710	58,500	24,400	286,738	369,638	39,300	23,400	223,386	286,086
WOOD PRODUCTION												
Timber Mgmt. Systems 2/ Acres	545,000	970,000	262,000	1,777,000	525,000	936,000	252,000	1,713,000	509,000	906,000	244,000	1,659,000
Thinning, Pruning Acres	15,000	18,000	3,000	36,000	15,000	18,000	3,000	36,000	10,000	9,000	2,000	21,000
Planting, Seeding Acres	1,000	10,000	7,000	18,000	1,000	10,000	7,000	18,000	1,000	6,000	4,000	11,000
ON FARM IRRIG SYSTEMS												
Canals and Ditches Miles	197	104	199	500	162	108	310	580	105	104	162	371
Irrig Water Control Structures No.	33,550	20,580	23,200	77,330	29,160	23,550	24,780	77,490	18,330	17,060	18,320	53,730
Land Leveling and Smoothing Acres	276,750	145,360	148,690	570,800	243,060	171,380	150,700	565,140	140,150	115,760	106,425	362,335
Drainage (Tile & Ditches) Miles	534	439	628	1,601	874	692	1,063	2,629	490	417	610	1,517
Drainage (Tile & Ditches) Acres	57,175	45,850	67,000	170,025	93,550	74,700	113,200	281,450	70,275	44,150	65,000	179,425
CROP PRODN IMPRVMT (DRY)												
Diversion Miles	15	7	40	62	31	15	81	127	15	7	40	62

1/ Includes Indian land.

2/ Grazing and timber management systems acreages are not cumulative by time frames.

production. This capability will be determined by the amount of forest land removed from timber production. The programs to be instituted to obtain such production are: (1) 42 marketing and utilization studies, (2) 852,000 acres of thinning and pruning, (3) tree planting and seeding 425,000 acres, and (4) timber inventory of 9.6 million acres. (See Tables 37 and 38 enumerating programs.)

Watershed management and flood control

Watershed management.--Average annual upstream watershed damage is presently $8.71 million. This will increase to $25.6 million by the year 2020 if no additional protection programs are initiated after 1965 due to population growth and economic activity. The program of upstream watershed management practices, including land treatment and water control structures, is listed in Tables 39 and 40. Man-created erosion and sediment production and associated damage will be decreased 40 to 60 percent. Upstream flood and sediment damage will be reduced 30 to 50 percent.

Flood control.--Average annual flood damage in the region would increase to an estimated value of $10,551,000 by year 2020 with no additional flood control measures after 1965 due to population growth and increased economic activity. A flood control plan consisting of flood control storage in reservoirs, levees, and channels; improved flood forecasting; land treatment; and other nonstructural measures would reduce the estimated average annual flood damage by $6,744,000 or would eliminate about 65 percent of the amount that would occur without the program. The structural components of the plan are shown in Table 41. Nonstructural measures such as zoning, flood proofing, use of building codes, subdivision regulations, and other similar techniques to limit flood damage at the principal urban areas of the region are also included in the plan.

Industrial activity

Thermal-electric power development.--By 2020 additional plants will be installed with a capacity of 40,820 megawatts, bringing the total installed capacity to 42,081 megawatts of thermal-electric power. Several small plants will be retired during the development period. Table 42 shows location and size of these power installations and retirements from the system.

Minerals.--Increased development of mineral fuels, primarily petroleum and uranium, together with bulk metal and nonmetal production of phosphate, potash, molybdenum, and trona are foreseen. Coal production will be adequate to meet needs for thermal power generation. Table 43 indicates the projected value distribution of the mineral industry by subregion and time frames. Oil shale developments were excluded because there was no history of this industry to project.

Table 39.--Projected watershed management program, Federal land summary, Framework Plan, Upper Colorado Region

PRACTICE	1966 - 1980				1981 - 2000				2001 - 2020			
	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL
EROSION, SEDIMENT & RUNOFF CONTROL												
Land Treatment												
Brush & Weed Control Acres	501,400	349,214	78,400	929,014	708,700	460,900	96,200	1,265,800	231,000	112,200	49,817	393,017
Watershed Tillage Acres	45,100	60,000	11,200	116,300	67,000	90,000	17,200	174,200	33,220	25,000	21,500	79,720
Seeding Acres	127,368	124,500	108,900	360,768	180,200	182,900	138,500	501,600	80,800	57,900	109,200	247,900
Stabilization Acres	1,532	3,050	8,075	12,657	1,532	3,060	8,065	12,657	300	610	1,457	2,367
Gully Control Miles	265	348	1,353	1,966	291	348	1,337	1,976	55	70	297	422
Sheet Erosion Control Acres	39,500	22,700	88,100	150,300	40,500	22,700	88,100	151,300	9,000	4,500	17,500	31,000
Water Control Detention Dams No.	130	20	34	184	205	33	69	307	113	19	82	214
Check & Drop Structures No.	1,049	12,746	834	14,629	2,584	19,284	2,223	24,091	3,735	5,266	3,772	12,773
Diversion Dams No.	55	12	33	100	120	23	87	230	129	22	126	277
Dikes No.	35	2	46	83	74	6	76	156	104	15	109	228
Streambank-lakeshore stabilization Miles	137	181	215	533	150	182	215	547	29	37	43	109
Debris Basins No.	1	4	13	18	-	5	12	17	-	1	2	3
WATER YIELD IMPROVEMENT 1/ Acres	60,700	55,800	260,210	376,710	62,400	55,800	261,210	379,410	12,300	11,000	52,142	75,442

1/ Includes snow pack management, ground water recharge (this may involve some of the same practices listed under Land Treatment and others such as pitting), specifically designated timber harvest.

Table 40.--Projected watershed management protection program, private land summary, Framework Plan, Upper Colorado Region 1/

PRACTICE	1966 - 1980				1981 - 2000				2001 - 2020			
	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL	Green	Upper Main Stem	San Juan-Colorado	REGION TOTAL
EROSION, SEDIMENT & RUNOFF CONTROL												
Land Treatment												
Watershed Tillage Acres	15,000	-	64,228	79,228	13,000	-	90,440	103,440	8,000	-	82,245	90,245
Tree & Shrub Planting Acres	60	-	1,006	1,066	50	-	915	965	40	-	673	713
Stabilization Acres	78,000	-	935	78,935	60,000	-	1,122	61,122	40,000	-	366	40,366
Water Control												
Detention Dams No.	210	-	351	561	180	-	384	564	100	-	198	298
Check & Drop Structures No.	1,846	-	5,765	7,611	1,000	-	4,189	5,189	500	-	2,381	2,881
Diversion Dams No.	450	260	424	1,134	480	500	468	1,448	240	260	304	804
Waterspreading Acres	8,975	13,475	117,260	139,710	16,000	26,950	106,246	149,198	7,950	13,475	73,352	94,777
Grade Stabilization Structures No.	150	-	161	311	300	-	322	622	150	-	161	311
Floodway Feet	5,000	3,250	2,400	10,650	10,000	6,500	4,900	21,400	5,000	3,250	2,400	10,650
Debris & Sediment Basins No.	60	85	670	815	120	170	1,340	1,630	60	85	670	815

1/ Includes Indian and State land.

Table 41 - Flood control programs
Framework plan
Upper Colorado Region

Subregion	Time frame	Multiple-purpose reservoir capacity (1,000 acre-feet)	Land treatment[1/] (1,000 acres)	Single-purpose programs: Reservoir capacity (1,000 acre-feet)	Single-purpose programs: Levees (miles)	Single-purpose programs: Channels (miles)
Green River	1980	466	974	21	0	0
	2000	123	1,302	46	5.4	3.6
	2020	75	527	28	0	0
Upper Main Stem	1980	1,172	641	7	0	3.0
	2000	293	873	20	2.0	0
	2020	0	308	6	0	0
San Juan-Colorado	1980	1	797	2	0	0
	2000	0	924	14	0	4.0
	2020	20	766	6	2.0	0
Region	1980	1,639	2,416	30	0	3.0
	2000	416	3,099	80	7.4	7.6
	2020	95	1,601	40	2.0	0
Region total		2,150	7,112	150	9.4	10.6

1/ Included in watershed management program.

Table 42 - Staging of thermal-electric power generating plants, framework plan, Upper Colorado Region

	Capacity (megawatts)	Location by state
Plants in service in 1965		
Durango	5	Colorado
Animas	31	New Mexico
Four Corners 1, 2, and 3	633	New Mexico
Oliver	3	Colorado
Cameo	75	Colorado
Bullock	10	Colorado
Nucla	38	Colorado
Rock Springs	25	Wyoming
Naughton No. 1	163	Wyoming
Carbon	189	Utah
Hayden No. 1	163	Colorado
Total in service - 1965	1,335	
Actual and proposed additions to 1980[1]		
Naughton No. 2	220	Wyoming
Naughton No. 3	330	Wyoming
Four Corners No. 4	795	New Mexico
Four Corners No. 5	795	New Mexico
San Juan No. 1 and No. 2	660	New Mexico
Navajo Nos. 1, 2, and 3	2,310	Arizona
Kaiparowits	2,400	Utah
Four Corners No. 6	800	New Mexico
Jim Bridger Nos. 1, 2, and 3	1,500	Wyoming
Emery County No. 1	330	Utah
Emery County No. 2	440	Utah
Hayden No. 2	500	Colorado
Craig	1,000	Colorado
Total additions	12,050	
Actual and probable plant retirement to 1980		
Rock Springs (actual)	25	Wyoming
Oliver	3	Colorado
Durango	5	Colorado
Total retirements	33	
Net plants in service - 1980	13,352	
Proposed additions 1981-2000[1]		
Blacksfork No. 1	1,200	Wyoming
Four Corners No. 7 and No. 8	1,600	New Mexico
San Juan No. 3	340	New Mexico
Kaiparowits	2,400	Utah
El Paso	1,500	New Mexico
Jim Bridger No. 4	500	Wyoming
Hayden No. 3	1,000	Colorado
Milner	1,000	Colorado
Northwest Colorado (not necessarily one plant)	11,700	Colorado
Upper Green No. 1	2,000	Wyoming
Upper Green No. 2	2,000	Wyoming
Sweetwater	2,000	Wyoming
West Central Colorado	1,500	Colorado
Total proposed additions	28,740	
Probable retirements 1981-2000		
Bullock	10	Colorado
Animas	31	New Mexico
Total retirements	41	
Net plants in service - 2000	42,051	

(No additions or deletions of installed capacity 2001-2020)

	Steamplant capacity in service				Depletions
State	1965 (megawatts)	1980 (megawatts)	2000 (megawatts)	2020 (megawatts)	(acre-feet) year 2000
Colorado	294	1,786	16,976	16,976	294,600
New Mexico	664	3,714	7,123	7,123	100,800
Wyoming	188	2,313	9,913	9,913	148,700
Utah	189	3,359	5,759	5,759	86,400
Arizona	0	2,310	2,310	2,310	34,100
Total	1,335	13,352	42,051	42,051	630,600

[1] The construction time sequence of the powerplants should not be construed as reflecting agreement by the power companies or the states as to priority of construction. Also, in addition to those listed as retired, other capacity will reach normal retirement age (30-35 years) during the study period. Retirement will depend on the then existing condition and the need for peaking and reserve capacity.

Table 43 - Projected value distribution among sectors of the minerals industry
Framework plan
Upper Colorado Region
(Unit--thousands of 1958 dollars)

Subregion and minerals	1980	2000	2020
Green River			
Oil and gas	172,000	155,700	48,000
Coal and gilsonite	84,000	358,500	342,200
Uranium and nonfuels	244,200	269,700	499,200
Subregion total	500,200	783,900	889,400
Upper Main Stem			
Coal	20,000	39,000	37,000
Oil and gas	4,000	3,600	1,100
Uranium	426,900	392,000	392,000
Zinc	20,800	20,800	20,800
All others	93,600	119,600	136,600
Subregion total	565,300	575,000	587,500
San Juan-Colorado			
Coal	65,000	127,000	122,000
Oil and gas	124,800	124,500	85,200
Uranium	240,400	244,300	298,600
All other	37,000	29,800	31,700
Subregion total	467,200	525,600	537,500
Region total	1,532,700	1,884,500	2,014,400

Municipal and industrial water.--Future municipal and industrial water supply requirements will be met by developing additional surface and ground water sources. In a few isolated cases, needs will be met by conversions of irrigation use to municipal and industrial uses. The amount of water these conversions represent is small, however. Use of surface sources will be by far the most common means and account for the largest segment of meeting the future needs. This is borne out by the fact that authorized projects are underway or will be constructed soon in all major areas of expanding needs. Where populations are lightly concentrated, multipurpose projects have been planned and, in many cases, are authorized with more than an adequate allocation for the municipal and industrial requirements developed from projections.

Because of the rural character of the region, however, there are wide areas where small community systems will be developed by non-Federal funds.

After considering the spatial relation of future needs to the delivery areas of authorized projects, it was estimated that 30, 20, and 30 percent of the future needs in each time frame projected for the Green River, Upper Main Stem, and San Juan-Colorado Subregions, respectively, would be met by non-Federal development.

Self-supplied systems delivering ground water will continue to make up a small portion of the future industrial supplies. The program includes installation of water development, conveyance, and treatment facilities.

Recreation and Fish and Wildlife

Recreation.--Recreation land and part of the water facilities will be made available for resident and nonresident use, totaling an increase of about 170 million recreation-days by 2020. About 435,000 acres of additional land will be developed for recreation needs. Undeveloped lands will be managed for optimum recreation use as well as other compatible uses. About 214,000 water acres will be suitable for meeting recreation needs; this includes 165,000 acres presently available but which, for various reasons, is not used for recreation.

Other programs to meet needs include existing multiple-use land primarily for recreation purposes. In addition, many large existing recreational areas could provide more opportunities if more access roads were built. This would increase operating efficiencies at areas presently not being used to capacity. In some instances, access might be obtained by some means other than roads, such as cable lifts or monorails, by buses rather than cars, or through more extensive use of hiking and riding trails.

It is important that detailed land use studies be completed to determine the best uses of all lands in the region. As a part of this type analysis, optimum carrying capacities of recreation lands should be established and the areas administered accordingly to prevent deterioration of

the resource base and to ensure quality experience to the recreationists. Since most of the demand for recreation opportunities is generated by nonresidents of the region and the quality of the region's recreation resource is still relatively high, special care should be taken to ensure well-planned development of facilities, and measures should be initiated to prevent overdevelopment, overuse, or misuse.

Special efforts will be made to increase opportunities for recreational use of water in streams and reservoirs. This will require road construction, right-of-way acquisition, maintenance of water quality, and revised legislation.

Many portions of existing streams and reservoirs are limited to use by a relatively few people because of physical and legal restraints. Both are factors that distort the computation of projected needs for recreation water. In other words, although no needs for additional water are shown before 2020, there is considerable need to make more effective recreational use of existing water.

An easily overlooked and difficult problem that relates directly to the enjoyment of the region's recreational resources by a majority of nonresidents concerns the availability of service facilities, especially lodging and restaurants. The sparse distribution of resident population and the few widely spaced urban concentrations, coupled with a short season of high use, make operations of this kind difficult to turn a profit and employ well-trained help. Development oriented to year-round rather than seasonal-type use might alleviate part of this problem.

Fish and wildlife.--Plans and programs for sport fishing facilities, including fishing impoundments, access developments, fish hatcheries, and habitat improvement and management, are planned to meet a fishing demand which will more than double. Sport hunting facilities and programs including land acquisition and/or development, access roads, and habitat management and improvement are planned for a hunting demand which will almost double. Table 44 lists the projected programs.

Export of Water

Facilities for exporting water from the basin to meet industrial, municipal, and full and supplemental irrigation needs have been built with a potential for increased diversion. Others are under construction or planned for construction. In Colorado existing facilities and enlargements of collection systems will provide most of the capacity for export. Some projects are under construction or are planned for construction in near future. The San Juan-Chama Project export facilities in Colorado and New Mexico are under construction for export of 110,000 acre-feet to the Rio Grande Basin in New Mexico. In addition, a study is underway to determine if it would be economical to divert 7,500 acre-feet of water from Navajo Reservoir to Gallup for municipal use. Utah is in the process of enlarging its facilities to export 166,000 additional acre-feet of water from the Uinta Basin to the Great Basin

Table 44 - Projected sport fishing and sport hunting facilities and programs
Framework plan
Upper Colorado Region

Type	1965-1980	1981-2000	2001-2020	Total
	Sport Fishing			
Construction of fishing impoundments (acres)1/	8,923	2,200	3,290	14,413
Acquisition of reservoir water rights (acre-feet)	9,192	3,000	-	12,192
Reservoir fishing leases (units)	3	6	5	14
Access development				
Streamside or lakeside (miles)	53	70	70	193
Roads (miles)	305	400	400	1,105
Public-use facilities (units)	654	1,300	1,400	3,354
Fish hatcheries (units)	5	1	3	9
Habitat improvement				
Stream (miles)	1,317	1,750	1,750	4,817
Impoundment or lake (acres)	2,412	3,200	3,200	8,812
Fish introduction2/ (number of species)	2	-	-	2
	Sport Hunting			
Land acquisition and/or development for				
Big game (acres)	37,420	50,000	50,000	137,420
Waterfowl (acres)3/	47,814	4,100	5,000	56,914
Access development				
Roads (miles)	200	270	270	740
Habitat improvement				
Range plant management (acres)	295,159	400,000	400,000	1,095,159
Waterhole development (units)	573	750	750	2,073
Fencing (miles)	711	1,000	1,000	2,711
Species management				
Wildlife stocking2/ (number of species)	10	-	-	10

1/ Acreage includes land and water requirements.

2/ Long-range projections uncertain because of research nature of the program.

3/ Needs beyond 1980 may change on the basis of overall flyway requirements.

through the Bonneville Unit of the Central Utah Project. This figure includes 29,500 acre-feet of reservoir evaporation associated with the transmountain diversion. Other developments are under study which could increase the total up to 467,000 acre-feet. Wyoming has constructed a part of the Cheyenne-Laramie transmountain diversions which will have an ultimate capacity of 31,000 acre-feet, and plans include additional diversion of 154,000 acre-feet to the North Platte River starting in 1980.

Water Quality, Pollution Control, and Health Factors

All agencies and organizations involved in making decisions about land and water resource use must continue to strengthen their programs for water quality management. This extends beyond those agencies specifically charged with water pollution control--although the primary responsibility rests with them--to all governmental authorities having lesser interests or control over activities that affect water quality. Development of complementary and mutually supporting programs by local, state, and Federal agencies will aid in meeting water quality objectives.

The search for solutions to the water quality problems must necessarily extend to an examination of existing legal systems and institutional arrangements to determine their efficacy in implementing any proposed plan for the management of water quantity and quality.

Because of the complexity and patterns of water uses, the varied water quality requirements, and the special requirements that may be needed to maintain the quality of recreational lakes, pollution control programs should fit into an overall scheme for water resources management for an entire river basin. Detailed basinwide planning for water quality control is essential to combat problems associated with salinity, nutrients, mine drainage, and electric power production. Continuing studies of the water quality problems anticipated are recommended. The maintenance of an acceptable level of water quality will become increasingly vital to the economy, environment, and general well-being of the people.

That portion of the Colorado River Basin salinity improvement program located in the Upper Colorado Region and outlined in the Water Quality, Pollution Control, and Health Factors Appendix consists of a salt load reduction program. This portion of the salinity improvement program would attempt to maintain concentrations at Lees Ferry at about 600 mg./l. Elements of the salinity control program located in the region include irrigation system improvements, desalination of springs near Glenwood Springs, Colorado, and bypass of a reach of the Dolores River. The technical feasibility of these projects needs to be proven before implementation of any program. In addition, arrangements for financing will require further study.

Methods for controlling mine drainage have not been developed for the "hardrock" mines of the West. Research and demonstration projects are needed to show the feasibility of abatement measures prior to implementation of a

program. Restoration of disturbed mining areas and control and stabilization of the tailings piles left after the processing of uranium and other metallic ores should be continued to reduce erosion and the contamination of water courses by the radioactive materials and heavy metals transported with the sediments. The distribution of the mine drainage problem is such that a large percentage of the investment in an abatement program would involve mines that are no longer operating and have no significant potential for producing any revenues.

As a part of the water quality standards, each state in the region established a minimum requirement of secondary treatment or its equivalent for municipal and industrial wastes. Advanced treatment methods are expected to be required in some areas, however, in order to remove nutrients from waste waters. Water quality managements plans are urgently needed in these areas to find economical and efficient solutions. It is assumed that technological advancements will result in progressively higher efficiencies of waste removal by secondary treatment throughout the study period. Removal of dissolved salts from municipal and industrial effluents for the specific purpose of alleviating salinity conditions is not expected.

Federal financial assistance programs are available which can pay from 30 to 55 percent of the cost of treatment facilities. Up to 50 percent of the cost of regional or basinwide planning may be obtained through Environmental Protection Agency grants.

Watershed protection is planned for forest, rangeland, irrigated land, and dry cropland to alleviate pollution from land runoff. The watershed management programs will have benefits on water quality, primarily by reducing the amounts of sediments and sediment-borne pollutants. Inasmuch as land uses and management practices have not been evaluated in terms of their net effect on water quality, it is suggested that agencies review their present management practices and alter them if necessary to conform with environmental goals.

If water quality control becomes recognized as a legitimate use, water resources management could provide for the optimum combination of quality and quantity for the available supply. In view of the scarce water supply and the ever-increasing importance of the quality of the supply, such opportunities should be fully evaluated.

To assure that detrimental effects on the environment from future power development will be minimized, planning should be expanded which would review locations of planned powerplants and evaluate thermal control and air pollution control methods with the ultimate objective of developing a long-range power-siting plan.

Environmental health programs are planned which will emphasize better protection and surveillance of public water supplies and initiate better control and monitoring of air pollution, solid waste disposal, radiological pollution, and disease vectors.

Costs

A summary of program costs for water development only is presented in Table 45. Summaries of the total program costs for water development plus associated development for the region and subregions are presented in Tables 46, 47, 48, and 49. Installation costs correspond to those structures or programs that will be needed to meet the framework plan requirements after the base year 1965. Operation, maintenance, and replacement costs are directly tied to the structures or programs to be installed and generally reflect the annual funds required at the end of the stated period. Cost estimates are in constant dollars indexed to 1965 levels.

Installation costs were estimated by the two general components, designated specific and joint facilities. Specific facilities are those readily identified with one major function with cost data drawn from the programs developed in the several appendices and costs for the facilities to convey water to the point of use by these programs. Joint facilities were those serving two or more functions such as reservoirs, main conveyances, structures, and collection systems. Joint costs were prorated to the applicable major function based upon proportionate use of the facility.

Included in the program costs for water development only are all joint costs and specific costs for municipal and industrial water supply; irrigation (except for on-farm systems) and drainage; hydropower generation, hydropower transmission, and conveyance systems to deliver cooling water to thermal-electric plants; flood control; water-based recreation; fishery improvements and waterfowl habitat development; water quality except salincontro; land management for erosion, sediment, and runoff control on all lands and water-yield improvements on Federal lands; and other water resource development, including export.

The installation costs of salinity control features for the combined Upper and Lower Colorado River Basins are estimated to be $241,000,000. The estimated annual operation and maintenance cost after completion of construction is $7,590,000. Salinity control costs are not included in the cost tables.

The program costs for associated development include specific costs for on-farm irrigation systems; thermal-electric plants and the transmission lines therefrom; nonwater-based recreation; and fish and wildlife for improving hunting, other than waterfowl hunting, by managing and improving the habitats, acquiring and improving access to hunting lands, and species management (stocking local species in new areas and introducing new species).

Adequacy of the Framework Plan

Land and water supply is generally not a limiting factor to obtaining the regionally interpreted OBERS level of development. In most sectors the proposed plans will meet regional objectives.

Table 49 - Summary of program costs for water development only
Framework plan
Upper Colorado Region
(Unit--$1,000, indexed to 1965)

Major Function	1966 - 1980		1981 - 2000			2001 - 2020			Total (1966 - 2020)		
	Installation	OM&R (Increm.)	Installation	OM&R Increm.	OM&R Cumul.	Installation	OM&R Increm.	OM&R Cumul.	Installation Specific	Installation Joint	Installation Total
1. M&I water supply	44,300	950	41,580	1,630	2,580	43,500	2,370	4,950	76,780	52,600	129,380
2. Irrigation	375,720	7,890	260,220	8,600	5,490	143,930	1,220	6,710	510,740	269,200	779,940
3. Electric power	115,100	4,730	162,060	9,760	14,490	0	0	14,490	208,160	69,000	277,160
4. Flood control	21,100	180	29,990	220	400	9,440	80	480	27,430	33,100	60,530
5. Recreation	182,280	1,600	200,630	2,610	4,210	302,210	3,790	8,000	471,720	213,400	685,120
6. Fish and wildlife	88,030	2,350	27,420	720	3,070	22,010	1,280	4,350	64,460	73,000	137,460
7. Water quality	19,400	970	12,800	820	1,790	15,400	1,040	2,830	47,600	0	47,600
8. Land management	47,670	2,290	55,880	410	2,700	23,490	(-1,040)	1,660	127,040	0	127,040
9. Other water resource development	296,700	1,580	283,700	1,520	3,100	98,800	700	3,800	564,400	114,800	679,200
Total program	1,190,300	17,540	1,074,350	20,290	37,830	668,780	9,440	47,270	2,098,330	825,100	2,923,430
Federal	936,340	5,010	699,600	2,470	7,480	388,190	2,070	9,550			2,304,130
Non-Federal	253,960	12,530	374,750	17,820	30,350	270,590	7,370	37,720			809,300

Table 50 - Total program costs for framework plan
Upper Colorado Region
(Unit--$1,000, indexed to 1965)

Major Function	1966 - 1980		1981 - 2000			2001 - 2020			Total (1966 - 2020)		
	Installation	OM&R (Increm.)	Installation	OM&R Increm.	OM&R Cumul.	Installation	OM&R Increm.	OM&R Cumul.	Installation Specific	Installation Joint	Installation Total
1. M&I water supply	44,300	950	41,580	1,630	2,580	43,500	2,370	4,950	76,780	52,600	129,380
2. Irrigation	404,340	4,580	288,280	4,260	8,840	163,470	2,360	11,200	586,890	269,200	856,090
3. Electric power	2,284,100	200,650	5,328,000	445,800	646,450	0	(-41,600)	604,850	7,543,100	69,000	7,612,100
4. Flood control	21,100	180	29,990	220	400	9,440	80	480	27,430	33,100	60,530
5. Recreation	623,850	9,880	897,020	15,940	25,820	1,640,820	21,810	47,630	2,948,290	213,400	3,161,690
6. Fish and wildlife	94,440	2,650	37,090	1,120	3,770	31,690	1,680	5,450	90,220	73,000	163,220
7. Water quality	19,400	970	12,800	820	1,790	15,400	1,040	2,830	47,600	0	47,600
8. Land management	102,910	12,050	138,200	1,760	13,810	53,340	(-720)	13,090	294,450	0	294,450
9. Other water resource development	296,700	1,580	283,700	1,520	3,100	98,800	700	3,800	564,400	114,800	679,200
Total program	3,891,140	233,490	7,056,660	473,070	706,560	2,056,460	(-12,280)	694,280	12,179,160	825,100	13,004,260
Federal	1,128,540	19,620	1,007,260	13,460	33,060	837,930	14,840	47,900			2,973,730
Non-Federal	2,762,600	213,870	6,049,400	459,610	673,480	1,218,530	(-27,120)	646,360			10,030,530

Table 47 - Program costs, regionally interpreted OBERS,
Green River Subregion,
Upper Colorado Region
(Unit--$1,000, indexed to 1962)

Major Function	1966 - 1980		1981 - 2000			2001 - 2020			Total (1966 - 2020)		
	Installation	OM&R (Increm.)	Installation	Increm.	Cumul.	Installation	Increm.	Cumul.	Specific	Joint	Total
1. M&I water supply	6,570	320	11,880	560	880	15,180	810	1,690	25,430	8,200	33,630
2. Irrigation	89,690	1,420	71,900	1,300	2,720	66,130	830	3,550	151,720	76,000	227,720
3. Electric power	811,400	72,400	4,002,400	340,300	412,700	0	(-23,800)	388,900	4,704,200	49,600	4,813,800
4. Flood control	6,860	110	14,310	80	190	2,480	20	210	5,750	17,900	23,650
5. Recreation	330,020	5,520	441,300	5,740	11,260	776,200	9,370	26,630	1,459,320	108,200	1,567,520
6. Fish and wildlife	32,780	1,160	14,190	260	1,420	12,050	510	1,930	31,480	27,600	59,080
7. Water quality	5,400	210	3,300	140	350	4,300	200	550	13,000	0	13,000
8. Land management	39,080	4,690	47,460	930	5,430	18,170	130	5,560	99,700	0	99,700
9. Other water resource development	149,500	720	229,100	1,100	1,820	96,600	520	2,340	374,800	100,400	475,200
Total program	1,466,300	86,460	4,835,830	350,510	436,770	991,110	-11,410	425,360	6,865,340	387,900	7,293,240
Federal	499,150	8,310	588,240	5,020	13,330	455,220	6,900	20,230			1,382,610
Non-Federal	1,057,150	78,150	4,307,590	385,290	423,440	535,890	(-18,310)	405,130			5,910,630

Table 48 - Program costs, regionally interpreted OBERS
Upper Main Stem Subregion,
Upper Colorado Region
(Unit--$1,000, indexed to 1962)

Major Function	1966 - 1980		1981 - 2000			2001 - 2020			Total (1966 - 2020)		
	Installation	OM&R (Increm.)	Installation	Increm.	Cumul.	Installation	Increm.	Cumul.	Specific	Joint	Total
1. M&I water supply	28,630	300	14,010	500	800	11,030	720	1,520	20,470	33,200	53,670
2. Irrigation	152,180	1,330	87,680	1,180	2,510	43,550	740	3,250	152,510	130,900	283,410
3. Electric power	59,200	750	269,800	24,300	25,050	0	(-1,300)	23,750	309,600	19,400	329,000
4. Flood control	10,970	60	6,180	70	130	3,620	30	160	9,570	11,200	20,770
5. Recreation	126,140	2,360	224,090	6,710	9,070	307,940	6,580	15,650	585,470	72,700	658,170
6. Fish and wildlife	29,560	580	12,470	440	1,020	6,990	430	1,450	20,820	27,800	48,620
7. Water quality	7,000	420	4,500	330	750	4,800	360	1,110	16,300	0	16,300
8. Land management	36,170	50	50,900	650	4,600	15,910	(-270)	4,330	102,980	0	102,980
9. Other water resource development	121,400	630	53,700	370	1,000	1,500	140	1,140	162,600	14,000	176,600
Total program	571,250	10,380	723,330	34,550	44,930	394,940	7,430	52,360	1,380,320	309,200	1,689,520
Federal	422,880	6,300	268,830	6,590	12,290	205,770	4,970	17,260			897,480
Non-Federal	148,370	3,980	454,500	28,660	32,640	189,170	2,460	35,100			792,040

Table 49 - Program costs, regionally interpreted OBERS
San Juan-Colorado Subregion,
Upper Colorado Region
(Unit--$1,000, indexed to 1965)

Major Function	1966 - 1980		1981 - 2000			2001 - 2020			Total (1966 - 2020)		
				OM&R			OM&R		Installation		
	Installation	OM&R (Increm.)	Installation	Increm.	Cumul.	Installation	Increm.	Cumul.	Specific	Joint	Total
1. M&I water supply	9,100	330	15,690	570	900	17,290	840	1,740	30,880	11,200	42,080
2. Irrigation	162,470	1,730	128,700	1,780	3,610	53,790	790	4,400	282,660	62,300	344,960
3. Electric power	1,413,500	127,500	1,055,800	81,200	208,700	0	(-16,500)	192,200	2,469,300	0	2,469,300
4. Flood control	3,270	10	9,500	70	80	3,340	30	110	12,110	4,000	16,110
5. Recreation	167,690	2,000	231,630	3,490	5,490	556,680	5,860	11,350	923,500	32,500	956,000
6. Fish and wildlife	32,100	910	10,430	420	1,330	13,050	740	2,070	37,980	17,600	55,580
7. Water quality	7,000	340	5,000	350	690	6,300	480	1,170	18,300	0	18,300
8. Land management	32,660	3,500	39,850	280	3,780	19,260	(-580)	3,200	91,770	0	91,770
9. Other water resource development	25,800	230	900	50	280	700	40	320	27,000	400	27,400
Total program	1,853,590	136,650	1,497,500	88,210	224,860	670,410	(-8,300)	216,560	3,893,500	128,000	4,021,500
Federal	296,510	4,910	210,190	2,550	7,460	176,940	2,970	10,430			683,640
Non-Federal	1,557,080	131,740	1,287,310	85,660	217,400	493,470	(-11,270)	206,130			3,337,860

Agricultural sector.--A combination of improved production from irrigated and dry cropland and the increased grazing from range and forest lands will provide an adequate base for meeting regional projections.

Irrigated cropland.--The plan will meet regionally interpreted OBERS production goals from irrigated lands by developing new land and water and increasing production on present lands.

Dry cropland.--The plan is adequate for increasing unit production on the remaining dry cropland acreage with about 100,000 acres being shifted to irrigated cropland during the study period.

Grazing.--The framework plan will require complementing programs to obtain about one-third the potential forage production increase obtainable in the basin; therefore, plan is adequate.

Timber production.--The plan is adequate to meet projected levels of production. However, it must be emphasized that the demand can only be met through a greatly accelerated management practices program.

Watershed management and flood control

Watershed management.--Upstream watershed management treatment programs will reduce the man-created erosion and sediment production and associated damage by 40 to 60 percent. The remaining damages are largely geologic in nature and not economically susceptible to treatment. Some natural problems may be susceptible to treatment. Upstream flood and sediment damage will be reduced about 30 to 50 percent.

Multipurpose reservoirs built on the stream system will trap sediment and reduce sediment contribution to many downstream areas. The plan is in agreement with existing protection and development programs.

Flood control.--The plans indicated herein would reduce average annual flood damages in the amounts shown in the tabulation below. Flood damages would be reduced to a reasonable level by structural and nonstructural measures of the plan. However, a large portion of the estimated future flood damage is located in the sparsely populated upstream nonurban areas where it is more difficult to provide the measures necessary to eliminate it.

Subregion	Estimated average annual flood damage reduction in $1,000		
	1980	2000	2020
Green River	302	1,053	2,115
Upper Main Stem	485	1,431	2,725
San Juan-Colorado	153	871	1,904
Total	940	3,355	6,744

Industrial activity

Thermal-electric power.--Thermal-electric generation proposed in the framework plan will meet all in-basin and a share of adjacent region requirements. There are additional coal resources in the basin, but available water supplies might limit further development.

Minerals.--Mineral production projected from the adequate resources can meet the projected requirements.

Municipal and industrial water development.--Planned development of municipal and industrial water supply can meet future needs.

Recreation - fish and wildlife

Recreation.--Generally, an adequate number of acres of land and water will be available to meet projected resident needs. Overall, about 64 percent of the water needs will be accommodated. Problems relating to use of these resources will have to be solved if demand is to be met. This will include providing adequate and legal access, suitable funding to build recreation facilities, and sufficient supporting services--especially food and lodging.

Presently proposed agency and state programs will meet only about 30 percent of the projected recreation-day needs by 2020.

Fish and wildlife.--Most of the region can expect to have enough game for its needs through 2020. The exceptions are Arizona and New Mexico, as in the case of future fishing needs. Wyoming also will have a significant shortage of resident game animals. A possibility for water for fisheries in Arizona and New Mexico would be the recommitment of developed water now dedicated to other uses. If wildlife conservation is given adequate recognition as a prominent objective of development and management in the key habitat areas, wildlife habitat will remain available and its capacity may possibly be improved.

However, the largest single factor that could obstruct wildlife objectives is the pressure for increased livestock capacity on range and forest lands. There is adequate potential for both preservation of wildlife and increased livestock use by balanced management methods, but more AUM's should not be attained at the expense of wildlife habitat capacity.

Export of water

The plan includes provisions to export water to adjacent regions. All water subject to distribution between regions is in accordance with existing approved compacts or legal agreements.

Water quality

Plans for controlling water quality are generally adequate in applying corrective measures that are physically possible and feasible.

Water supply situation

After development of the framework plan as described, approximately 8.3 MAF of outflow would pass Lee Ferry in the year 2020 (figure following page 134).

Economic Impact

To indicate the economic growth associated with the framework plan, agriculture and some other sectors of the economy were analyzed by an imput-output model. However, the economic projections were made independently for sectors such as minerals, forestry, and electric power. Figures are tabulated below for population, employment, personal income, and the gross regional product.

Population projections

Subregion	1980	2000	2020
Green River	116,989	145,876	173,424
Upper Main Stem	168,618	185,305	213,289
San Juan-Colorado	150,337	202,915	273,464
Region	435,944	534,096	660,177

This population projection is based upon economic subregions and does not include the 64,300 population independently projected for 2020 for the hydrology portion of Arizona in the Upper Colorado Region.

Population density would increase from 3.8 per square mile in 1980 to 5.8 in 2020 for the economic subregions.

Employment.--Coefficients were used in connection with projected total gross outputs to project the employment figures shown below.

Subregion	1980	2020	2020
Green River	42,233	55,287	65,381
Upper Main Stem	62,726	73,566	85,742
San Juan-Colorado	50,363	72,035	100,088
Region	155,322	200,888	251,211

Employment is projected to increase 126 percent for the region from 1965 to 2020.

Personal income.--Personal income projections reflecting economic activity were obtained by multiplying the projected per capita income by the population projections (OBE) as shown in the tabulation on page 135.

UPPER COLORADO REGION

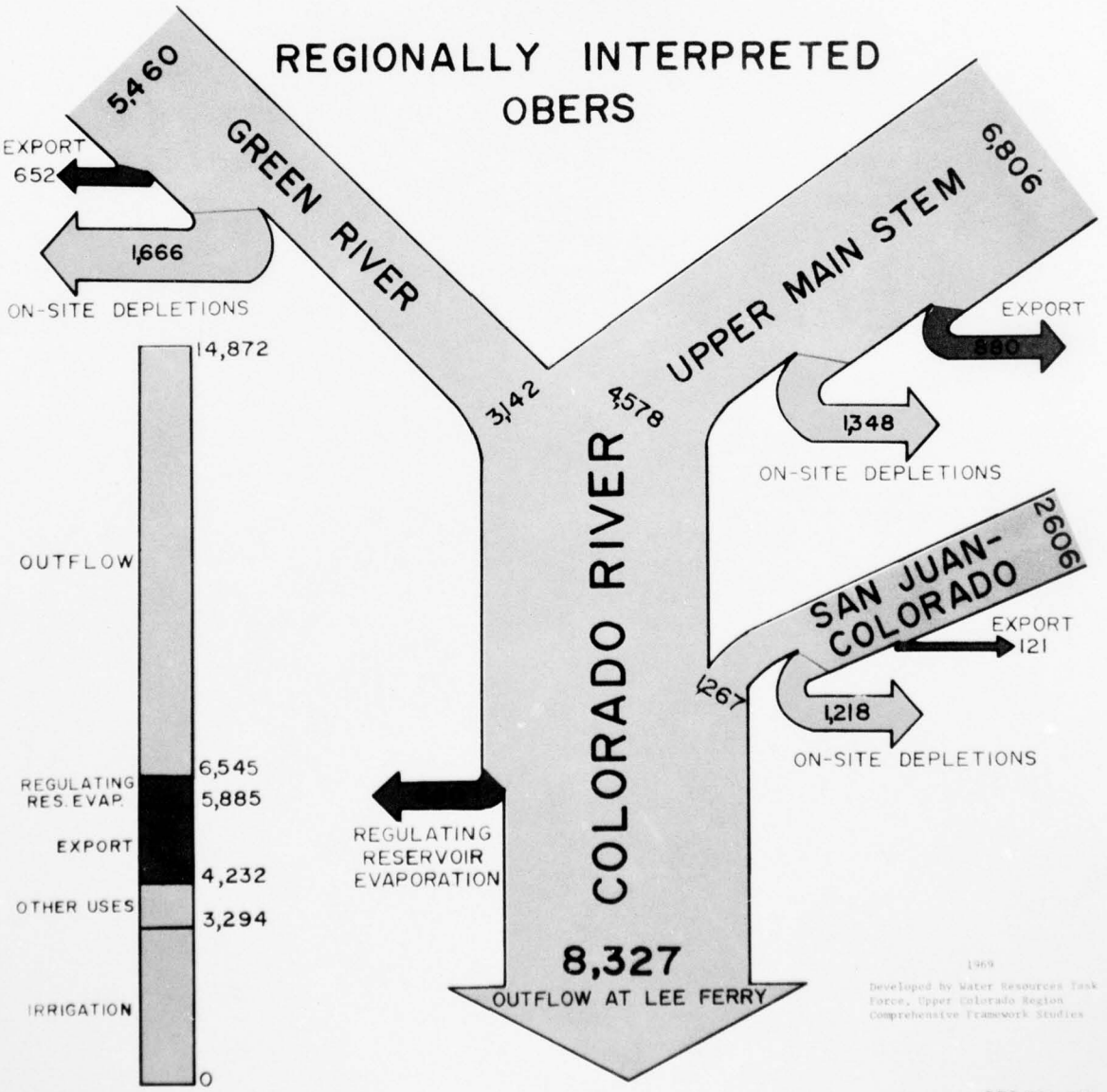
WATER SUPPLY (1914-1965),

ON-SITE DEPLETIONS & OUTFLOW FOR 2020

(In Thousands of Acre Feet)

YEAR 2020

REGIONALLY INTERPRETED OBERS



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Developed by Water Resources Task Force, Upper Colorado Region Comprehensive Framework Studies

GPO 858-936

Subregion	1980	2000	2020
	(Thousands of dollars)		
Green River	468,775	1,070,730	2,206,127
Upper Main Stem	589,320	1,139,070	2,326,770
San Juan-Colorado Region	518,813	1,262,131	3,039,005
	1,576,908	3,471,931	7,571,902

The major components of personal income are wage and salary payments, proprietor's income, property income, and income payments under social security, pensions, and similar funds.

Gross regional product.--Gross regional product (GRP) is the sum of the four major expenditure components in the regional economy. These are (1) personal consumption expenditures, (2) Government purchases of goods and services, (3) gross private investment, and (4) net export of goods and services.

Subregion	Gross regional product		
	1980	2000	2020
	(Thousands of dollars)		
Green River	735,887	1,595,067	3,107,250
Upper Main Stem	870,365	1,630,428	3,257,425
San Juan-Colorado Region	813,377	1,751,784	4,105,192
	2,419,629	4,977,279	10,469,867

Environmental Considerations

Economic development to meet the projected needs with minimum adverse effects on the natural environment of the region has been a basic goal in formulating the framework plan. Many programs and functions have been outlined that would protect and contribute to the overall quality of living in the region in addition to providing the basic economic opportunities. These programs have been described in preceding sections.

It is unfortunate that most conservation practices damage or destroy the archeological resource base which is the sole source of information on the history of the American Indian prior to accounts of the European explorers. A properly planned and adequately funded program of investigations and salvage of these resources which will be affected by developments will tend to mitigate this adverse effect.

Practically all programs and developments would increase the consumptive use of water and impact on the land in varying degrees. Development of water resources in many instances requires storage to regulate the

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UPPER COLORADO REGION COMPREHENSIVE FRAMEWORK STUDY. APPENDIX X--ETC(U)
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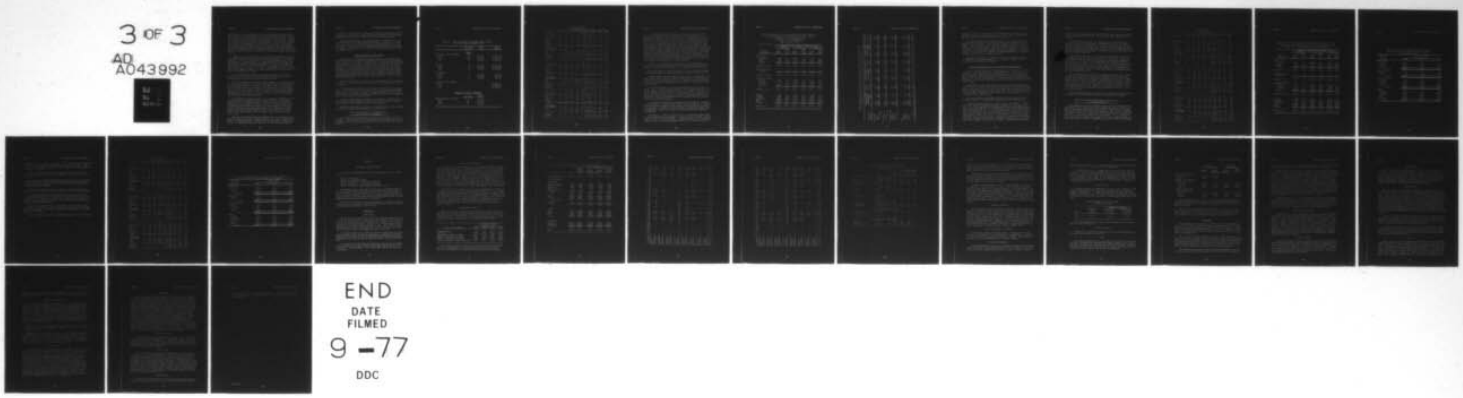

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efficient utilization. Construction of these reservoirs in turn causes some disruption on stream regimen, on fish and wildlife habitat, and natural features of the environment. However, with proper planning considerations, many values are created that compensate for the changes. Streams are often regulated for flood control, sediment is removed, water quality fluctuations are diminished, and the stream is converted to conditions that support a higher type of fish life. Reservoirs themselves provide abundant fishing and other water-based recreation in this area where natural bodies of water are few in number and widely spaced. Detailed requirements to control pollution at construction sites are included in most contracts.

Addition to the irrigated land base of 500,600 acres would cause loss of big-game habitat and conversion of the wildlife population to a farm-game type. Additional contribution of dissolved materials, pesticides, and nutrients to streams would occur unless proper control measures are developed and applied. Watershed management for flood control may have minor effects on fish and wildlife habitat and esthetics but will contribute materially to control of sediment, improvement of vegetative cover, reduce flood damages, improve base flows, provide open spaces on flood plains, and protect frail lands.

Eliminating present abuses and placing all grazing on a sustained yield-basis will alleviate most of the adverse effects connected with grazing and provide for the required forage production.

Mineral development can produce a great abundance of needed minerals for the region and Nation. If this development is managed property, it can be accomplished with a minimum of detrimental effect. Strip mining regulations can provide for reshaping and revegetation; land subsidence can be controlled by leaving sufficient support or refilling underground excavations or introduction of water to replace liquid petroleum. Proper management would be required to regulate disposal of tailings and polluted drainage from mining operations.

The tremendous increase projected in development of thermal-electric power would use a substantial amount of water but would occupy only a relatively small land area for plant and associated mining activities. Problems that need careful attention to minimize adverse impacts on the environment include disposal of waste heat, stack emissions, and location and construction of large transmission lines. Emission of sulfur products from fossil-fueled plants is less of a problem in the region than in other areas owing to the low sulfur content of most of the region's coal.

The region now provides unexcelled opportunity for recreation to enhance the quality of living for nonresidents as well as the comparatively sparse resident population. However, if projected needs are met in the future, a tremendous increase in pressure is anticipated and careful

consideration must be given to managing the natural environment to avoid unwarranted deterioration. Proper design and management of resort areas, campgrounds, and other facilities would alleviate concentrations.

The projected increase in population leaves the region with a very low average density and few urban concentrations. Construction is projected to alleviate the present backlog of sewage treatment facilities and upgrade treatment for future time periods. Plans have also been made for control of air pollution, solid waste disposal, radiological hazards, and disease vectors.

OBERS As Published - March 1968

Early study of the March 1968 OBERS projections for agriculture revealed inconsistencies that were incompatible with the history of agricultural production in the Upper Colorado Region. The primary departure from established practice was the projected source of livestock feed required to meet the livestock production assigned to the region by the national projections. The published projections of feed output were not adequate to produce the livestock output without feed imports from outside the region which were unrealistically high, while a tremendous surplus of pasture and range went unused within the region under the best ration and feeding efficiency procedure. Feeder livestock would also have to be imported for feedlots.

Table 50 illustrates this problem. It was agreed that the projection of livestock was more reliable and important than the projection of livestock feed.

If imports were assumed to be the method of supplying the necessary feed, a net reduction of 70,700 acres of irrigated land would ensue from 1965 to 2020. This would, in turn, be totally incompatible with present detailed plans contained in Federally authorized projects and contemplated private developments of 401,500 acres.

Because of these reasons and many other technical considerations associated with the development of model coefficients, no further studies were attempted for the agricultural sector as published.

Minerals, power, and timber were also adjusted to more nearly conform to planned and anticipated development in these sectors.

States' Alternative to the Framework Plan 6.5 MAF Level of Development

For comparative purposes and to express states' desires, the states proposed an alternative to the framework plan at the 6.5 MAF level of development. Data on proposed water uses for this alternative are shown in Table 51.

Table 50 - Feed crop imports and range forage surplus, 1968 OBERS, Upper Colorado Region

	Unit price (per ton)	Amount (tons)	Value (dollars)
	Imports		
Feed grain, corn equivalent			
1980	$40	163,470	$6,538,800
2000	40	405,208	16,208,320
2020	40	648,517	25,940,680
Hay			
1980	25	492,806	12,320,150
2000	25	598,576	14,964,400
2020	25	572,266	14,306,650
Corn silage			
1980	8	95,612	764,890
2000	8	107,975	863,800
2020	8	100,200	801,600
Total feed crop imports			
1980			19,623,840
2000			32,036,520
2020			41,048,930
	Surplus of Present Production		
	Unit price	Amount (AUM's)	
Surplus pasture and range			
1980	NA	221,473	
2000	NA	506,368	
2020	NA	745,790	

Table 51 - Water use for the States' alternative to the framework plan (6.5 MAF level of development) 1980, 2000, and 2020
Upper Colorado Region

Type of use	On-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Green River	Upper Main Stem	San Juan-Colorado
					1980				
Municipal and industrial	2,900	22,100	7,200	10,100	4,300	46,600	12,200	16,200	18,200
Electric power (thermal)	34,100	10,700	90,000	125,400	33,200	293,400	56,700	1,600	235,100
Minerals	400	19,500	11,800	10,300	19,000	61,000	31,500	13,700	15,800
Fish and wildlife	1,200	38,800	6,800	22,200	18,800	87,800	49,400	7,900	30,500
Recreation	100	700	100	1,000	200	2,100	800	700	600
Stock-pond evaporation and livestock use	1,400	25,000	2,900	7,300	4,800	41,400	15,300	13,700	12,400
Subtotal	40,100	116,800	118,800	176,300	80,300	532,300	165,900	53,800	312,600
Irrigation: consumptive use, incidental use, and reservoir evaporation	7,000	1,391,100	245,000	576,600	334,000	2,553,700	935,400	1,007,800	610,500
Export		663,400	117,500	190,000	65,000	1,035,900	255,000	660,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,171,300	481,300	940,300	479,300	4,119,300	1,356,300	1,722,500	1,040,500
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,779,300	1,423,300	1,739,500	1,616,500
					2000				
Municipal and industrial	4,800	48,300	13,600	16,800	5,900	89,400	19,100	38,900	31,400
Electric power (thermal)	34,100	108,200	90,000	261,800	148,700	642,800	331,100	16,600	295,100
Minerals	300	128,300	17,400	10,300	22,100	178,400	32,900	109,200	36,300
Fish and wildlife	1,200	39,400	6,800	22,200	18,800	88,400	49,500	8,400	30,500
Recreation	300	1,100	100	1,600	200	3,300	1,400	900	1,000
Stock-pond evaporation and livestock use	1,700	30,500	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	355,800	131,200	321,700	201,500	1,052,600	452,200	191,100	409,300
Irrigation: consumptive use, incidental use, and reservoir evaporation	7,600	1,778,200	329,000	660,600	407,000	3,182,400	1,197,500	1,184,500	800,400
Export		885,400	117,500	267,000	150,000	1,419,900	417,000	882,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,019,400	577,700	1,246,700	758,500	5,652,300	2,066,700	2,258,500	1,327,100
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2000						6,312,300	2,133,700	2,275,500	1,903,100
					2020				
Municipal and industrial	7,200	70,000	29,100	32,100	9,200	147,600	35,600	54,400	57,600
Electric power (thermal)	30,100	108,200	55,600	261,800	148,700	604,400	331,100	16,600	256,700
Minerals	300	124,500	32,500	52,900	21,500	231,700	67,900	113,300	50,500
Fish and wildlife	1,200	39,400	6,800	22,200	18,800	88,400	49,500	8,400	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stock-pond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	379,500	128,200	382,300	205,300	1,136,300	507,500	214,600	414,200
Irrigation: consumptive use, incidental use, and reservoir evaporation	9,000	1,754,500	411,000	695,200	427,100	3,296,800	1,253,300	1,166,500	877,000
Export		885,400	117,500	267,000	185,000	1,454,900	452,000	882,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,019,400	656,700	1,341,900	817,400	5,885,400	2,212,800	2,264,000	1,408,600
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						6,545,400	2,279,800	2,281,000	1,984,600

In the framework plan, there is need to service a large electric power market from potential fuel-burning electric powerplants in the Upper Colorado Region. Each of the States of Colorado, New Mexico, Utah, and Wyoming anticipated that a part of their coal and water resources will be used for the production of such energy. Previously the states had agreed to maintain proportionate levels of water development very close to their respective percentage allotments in the Upper Colorado River Compact. Without upsetting a multitude of water uses set forth in the framework plan, the approximate state percentages could be maintained only by an arbitrary assignment to each state of portions of the needed thermal-electric power installations as necessary to bring each state's total water uses to amounts approximating the compact percentages. Although this assignment depicted a reasonable satisfaction, on a region-wide basis, of the requirements for the framework plan, there were certain features objectionable to Colorado and Utah.

Changes in uses from those contained in the framework plan, are described in the following narrative. Tables 52 and 53 provide further details on proposed thermal-electric and irrigated land development.

Arizona retained its exact allotment of 50,000 acre-feet per annum in the revised year 2020 distribution with no change in types of use.

Colorado varied its water depletions for full and supplemental irrigated land by 88,000 acre-feet less in 1980; 145,000 acre-feet more in 2000; and 31,500 acre-feet more in 2020. Irrigated land acreage varied by 18,000 less acres in 1980; 80,000 more acres in 2000; and 6,500 more acres in 2020.

Oil shale industry in the Green and Upper Main Stem Subregions totaling 1 million barrels-per-day capacity, with a support population of 78,000, depleting 97,000 acre-feet annually, was added by the year 2020. A coal byproducts plant, using 15,000 acre-feet, and a potash plant, capacity 1.5 million tons annually, using 9,500 acre-feet annually, are projected. Exports are increased by 2,400 acre-feet and fish and wildlife by 600 acre-feet annually.

It appears that Colorado would deplete its 51.75-percent allotment by the year 2000. Thermal-electric power installed capacity is lessened by 9,690 megawatts from the framework plan, depleting 146,400 acre-feet less annually. In addition, 22,100 acre-feet of irrigation water would be transferred between 2001 and 2020 to meet municipal and industrial requirements.

New Mexico, in order to stay within its 11.25-percent apportionment of the 6.5 MAF level of development, changed its uses involving a net decrease of 9,500 acre-feet annually. A large reduction, 51,200 acre-feet, resulted from an arbitrary programmed reduction in installed generating

Table 52 - Projected installed capacity and water depletions for thermal-electric power generation for the states' alternative to the framework plan (6.5 MAF level of development) Upper Colorado Region

Subregion and state	Installed capacity and consumptive use					
	1980		2000		2020	
	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet
Green River						
Colorado	663	9.1	4,663	69.1	4,663	69.1
Utah	959	14.4	7,559	113.3	7,559	113.3
Wyoming	2,213	33.2	9,913	148.7	9,913	148.7
Subregion total	3,835	56.7	22,135	331.1	22,135	331.1
Upper Main Stem						
Colorado	123	1.6	1,123	16.6	1,123	16.6
Subregion total	123	1.6	1,123	16.6	1,123	16.6
San Juan-Colorado						
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	0	0	1,500	22.5	1,500	22.5
New Mexico	5,623	90.0	5,623	90.0	5,623	55.6
Utah	7,400	111.0	9,900	148.5	9,900	148.5
Subregion total	15,333	235.1	19,333	295.1	19,333	256.7
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	786	10.7	7,286	108.2	7,286	108.2
New Mexico	5,623	90.0	5,623	90.0	5,623	55.6
Utah	8,359	125.4	17,459	261.8	17,459	261.8
Wyoming	2,213	33.2	9,913	148.7	9,913	148.7
Region total	19,291	293.4	42,591	642.8	42,591	604.4

Table 53 - Projected on-site water depletions by irrigated land (new and supplemental), incidental use, and irrigation reservoir evaporation for the states' alternative to the framework plan (6.5 MAF level of development), Upper Colorado Region

Hydrologic subregion and state	1980 Irrigated land (1,000 acres) Total	1980 Irrigated land (1,000 acres) Supplemental 1/	1980 Water depletions (1,000 acre-feet)	2000 Irrigated land (1,000 acres) Total	2000 Irrigated land (1,000 acres) Supplemental 1/	2000 Water depletions (1,000 acre-feet)	2020 Irrigated land (1,000 acres) Total	2020 Irrigated land (1,000 acres) Supplemental 1/	2020 Water depletions (1,000 acre-feet)
Green River									
Colorado	129.3	6.1	124.8	192.2	17.1	257.9	193.2	17.1	258.6
Utah	286.8	31.0	476.6	295.7	102.6	532.6	314.8	102.6	567.6
Wyoming	341.5	59.0	334.0	379.5	85.0	407.0	392.5	95.0	427.1
Subtotal	757.6	96.1	935.4	867.4	204.7	1,197.5	900.5	214.7	1,253.3
Upper Main Stem									
Colorado	646.4	25.7	991.1	727.2	99.3	1,167.3	718.2	99.3	1,149.3
Utah	9.6	2.0	16.7	9.7	2.0	17.2	9.7	2.0	17.2
Subtotal	656.0	27.7	1,007.8	736.9	101.3	1,184.5	727.9	101.3	1,166.5
San Juan-Colorado									
Arizona	10.0	0	7.0	9.4	1.0	7.6	9.4	2.0	9.0
Colorado	209.7	28.7	275.2	248.0	53.8	353.0	247.0	53.8	346.6
New Mexico	104.2	5.5	245.0	174.2	5.5	411.0	174.2	5.5	411.0
Utah	54.4	0	83.3	65.7	7.0	110.8	59.1	14.6	110.4
Subtotal	378.3	34.2	610.5	497.3	67.3	882.4	489.7	75.9	877.0
Region									
Arizona	10.0	0	7.0	9.4	1.0	7.6	9.4	2.0	9.0
Colorado	985.4	60.5	1,391.1	1,167.4	170.2	1,778.2	1,158.4	170.2	1,754.5
New Mexico	104.2	5.5	245.0	174.2	5.5	411.0	174.2	5.5	411.0
Utah	350.8	33.0	576.6	371.1	111.6	660.6	383.6	119.2	695.2
Wyoming	341.5	59.0	334.0	379.5	85.0	407.0	392.5	95.0	427.1
Total	1,791.9	158.0	2,553.7	2,101.6	373.3	3,264.8	2,118.1	391.9	3,296.8

1/ Supplemental acreage included in total.

capacity. However, mineral production would materially increase, and an additional municipal and industrial use of 11,800 acre-feet annually was projected owing to a population increase of 64,500.

Utah desired that a much greater portion of its potential thermal-electric power production be included and projected an additional 11,700 megawatts to be installed. This required a support population of 26,000 people. Utah also added an oil shale industry with a capacity of 500,000 barrels per day with a support population of 39,000 people. In order to stay within its 23-percent allotment Utah revised downward its irrigation acreage (-10,500 acres) and likewise revised downward (-200,000 acre-feet annually) its export to the Bonneville Basin.

Wyoming also suggested no changes in its type of uses but revised its irrigation depletions downward 900 acre-feet per annum to stay exactly within its 14-percent allotment.

States' Alternative at the 8.16 MAF Level of Development

This is an alternate plan of development which reflects 8.16 million acre-feet of man-made depletions in the Upper Basin. It includes the amounts of water evaporated from mainstem reservoirs. This plan assumes the Colorado River water supply would be firmed to meet the division of water by the Colorado River Compact. Proposed depletion distribution among the states in 2020 equals their percentage shares under the Upper Colorado River Compact.

Development of some resources would not be limited by present water availability. The States have assumed that a market for the increased production associated with this level of development would readily be absorbed within national and increasing western markets. This is especially true since the added increment is a small part of the national market and would accordingly have a small impact.

Arizona retained its allotment of 50,000 acre-feet for 2020 with no changes in types of uses previously described for the framework plan.

Colorado plans to irrigate 1,256,300 acres in 2020, which is 104,400 acres more than the framework plan, with a depletion of 1,941,500 acre-feet. Oil shale complexes, in the Upper Main Stem and in the Green River, each having a capacity of 1 million-barrels-per day, would deplete 194,000 acre-feet annually by 2020. A coal byproducts plant, using 15,000 acre-feet in the San Juan-Colorado, and a potash plant, capacity of 1.5 million tons annually, using 9,500 acre-feet, are projected. Fish and wildlife uses would total 71,400 acre-feet, a substantial increase over the framework plan. Thermal-electric power capacity of approximately 10,000 megawatts would deplete 153,200 acre-feet annually. Export would increase to

1.36 million acre-feet annually. This plan would meet regionally interpreted OBERS requirements for all sectors except power, which would be met by Utah.

New Mexico plans no changes in agriculture, fish and wildlife, or recreation from the framework plan. Population by 2020 is estimated at 189,500 and the minerals industry is projected to increase as a result of available reserves and national need. Thermal-electric powerplant installed capacity would be 5,623 megawatts. Export to the Rio Grande Basin via the San Juan-Chama Project would be increased 125,000 acre-feet for a total export of 243,000 acre-feet.

Utah would increase its use by irrigated crops 10,700 acre-feet over the framework plan and irrigate about 401,200 acres by 2020. There are no changes in fish and wildlife, recreation, or stock-pond evaporation and livestock use. Export to the Great Basin by 2020 would increase to 447,000 acre-feet, which is 20,000 acre-feet less. Major changes are in increased thermal-electric power to 19,500 megawatts installed capacity and increased mineral activity, including mining coal for powerplants, a million barrel-per-day shale oil output, processing oil-impregnated sandstone and conversion of coal.

Wyoming's development includes a substantial increase in the mineral industry, including a million barrel-per-day shale oil production, depleting 97,000 acre-feet of water, and conversion of coal. Trona plant capacity would continue to increase. Population would increase to 148,000 by the year 2020. The agricultural base of irrigated land would increase to 513,300 acres by year 2020. Thermal-electric power installed capacity is estimated at almost 10,000 megawatts. Transbasin diversions to the North Platte River are estimated at 153,000 acre-feet, which is a 32,000-acre-foot reduction.

Table 54 enumerates water uses for this alternative and Tables 55 and 56 summarize projected thermal-electric and irrigation developments.

States' Alternative--Water Supply Available Site (9.44 MAF Depletions)

Development which would be possible if the states of the Upper Colorado Region utilize water which would be physically available at site of project development is described briefly below. There has been no agreement between the states or within the states that this can be accomplished in the way indicated, but rather this discussion indicates utilization of water that is physically available for development. It is contemplated that there would be shifts between types of use as the needs develop. The plan would require substantial augmentation to meet Colorado River Compact

Table 54 - Water use for the States' alternative at the 8.1[6] MAF level of development, 1980, 2000, and 2020
Upper Colorado Region

Type of use	On-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Green River	Upper Main Stem	San Juan-Colorado
				- - 1980 - -					
Municipal and industrial	2,900	22,100	7,200	10,100	5,500	47,800	13,400	16,200	18,200
Electric power (thermal)	34,100	10,700	90,000	125,400	22,000	282,200	45,500	1,600	235,100
Minerals	400	19,500	19,800	10,300	23,900	73,900	36,400	13,700	23,800
Fish and wildlife	1,200	38,800	6,800	22,200	20,100	89,100	50,700	7,900	30,500
Recreation	100	700	100	1,000	200	2,100	800	700	600
Stockpond evaporation and livestock use	1,400	25,000	2,900	7,300	4,800	41,400	15,300	13,700	12,400
Subtotal	40,100	116,800	126,800	176,300	76,500	536,500	162,100	53,800	320,600
Irrigation: consumptive use, incidental and reservoir evaporation	7,000	1,391,100	243,000	576,600	431,500	2,651,200	1,032,900	1,007,800	610,500
Export		663,400	117,500	190,000	65,000	1,035,900	255,000	660,900	120,000
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,171,300	489,300	940,300	573,000	4,221,000	1,450,000	1,722,500	1,048,500
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,881,000	1,517,000	1,739,500	1,624,500
				- - 2000 - -					
Municipal and industrial	4,800	50,000	13,600	20,200	7,300	95,900	29,500	31,900	34,500
Electric power (thermal)	34,100	153,200	90,000	291,800	37,000	606,100	234,400	61,600	310,100
Minerals	300	128,300	38,800	10,700	47,100	225,200	99,600	67,700	57,900
Fish and wildlife	1,200	39,400	6,800	22,200	20,100	89,700	50,800	8,400	30,500
Recreation	300	1,100	100	1,600	200	3,300	1,400	900	1,000
Stockpond evaporation and livestock use	1,700	30,300	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	402,500	152,600	355,500	117,500	1,070,500	433,900	187,600	449,000
Irrigation: consumptive use, incidental and reservoir evaporation	7,600	1,792,500	411,000	660,600	534,500	3,406,200	1,325,000	1,198,800	882,400
Export		925,400	243,000	437,000	125,000	1,730,400	602,000	882,900	245,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,120,400	806,600	1,450,500	777,000	6,204,500	2,360,900	2,269,300	1,574,300
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2000						6,864,500	2,427,900	2,286,300	2,150,300
				- - 2020 - -					
Municipal and industrial	7,200	84,100	29,100	42,500	28,900	191,800	78,300	54,400	59,100
Electric power (thermal)	30,100	153,200	90,000	291,800	148,700	713,800	346,100	61,600	306,100
Minerals	300	207,500	54,000	165,600	122,700	550,100	364,600	113,300	72,200
Fish and wildlife	1,200	71,400	6,800	22,200	20,100	121,700	50,800	40,400	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stockpond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	553,600	184,100	535,400	327,500	1,641,600	863,200	291,600	486,800
Irrigation: consumptive use, incidental and reservoir evaporation	9,000	1,941,500	411,000	733,700	562,500	3,657,700	1,470,100	1,262,600	925,000
Export		1,360,300	243,000	447,000	153,000	2,203,300	640,000	1,305,800	257,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,855,400	838,100	1,713,500	1,043,000	7,500,000	2,973,300	2,860,000	1,666,700
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						8,160,000	3,040,300	2,877,000	2,242,700

Table 55 - Projected installed capacity and water depletions for thermal-electric power generation for states' alternative at the 8.16 MAF level of development, Upper Colorado Region

Subregion and state	Installed capacity and consumptive use					
	1980		2000		2020	
	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet	Mega-watts	1,000 acre-feet
Green River						
Colorado	663	9.1	4,663	69.1	4,663	69.1
Utah	959	14.4	8,559	128.3	8,559	128.3
Wyoming	1,463	22.0	2,463	37.0	9,913	148.7
Subregion total	3,085	45.5	15,685	234.4	23,135	346.1
Upper Main Stem						
Colorado	123	1.6	4,123	61.6	4,123	61.6
Subregion total	123	1.6	4,123	61.6	4,123	61.6
San Juan-Colorado						
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	0	0	1,500	22.5	1,500	22.5
New Mexico	5,623	90.0	5,623	90.0	5,623	90.0
Utah	7,400	111.0	10,900	163.5	10,900	163.5
Subregion total	15,333	235.1	20,333	310.1	20,333	306.1
Arizona	2,310	34.1	2,310	34.1	2,310	30.1
Colorado	786	10.7	10,286	153.2	10,286	153.2
New Mexico	5,623	90.0	5,623	90.0	5,623	90.0
Utah	8,359	125.4	19,459	291.8	19,459	291.8
Wyoming	1,463	22.0	2,463	37.0	9,913	148.7
Region total	18,541	282.2	40,141	606.1	47,591	713.8

Table 56 - Projected irrigated acreage for States' alternative at the 8.16 MAF level of development
Upper Colorado Region

Hydrologic Subregion and State	Irrigated land (1,000 acres)		
	1980	2000	2020
Green River			
Colorado	129.3	192.2	217.4
Utah	286.8	295.7	312.9
Wyoming	421.3	494.8	513.3
Subtotal	837.4	982.7	1,043.6
Upper Main Stem			
Colorado	646.4	727.2	771.8
Utah	9.6	9.7	8.0
Subtotal	656.0	736.9	779.8
San Juan-Colorado			
Arizona	10.0	9.4	9.4
Colorado	209.7	255.0	267.1
New Mexico	104.2	174.2	174.2
Utah	54.4	65.7	80.3
Subtotal	378.3	504.3	531.0
Region			
Arizona	10.0	9.4	9.4
Colorado	985.4	1,174.4	1,256.3
New Mexico	104.2	174.2	174.2
Utah	350.8	371.1	401.2
Wyoming	421.3	494.8	513.3
Total	1,871.7	2,223.9	2,354.4

requirements for delivery at Lee Ferry. If the Colorado River is augmented below Lake Powell, exchange arrangements would have to be made. Proper consideration of possible detriment to power revenues and of augmentation costs will be required.

Additional uses of 1.28 million acre-feet above the 8.16 MAF level are described briefly by state, and a summary of total uses is shown in Table 57.

Colorado has identified additional uses by 2020, which would increase export to the eastern slope of the Rocky Mountains by 113,000 acre-feet annually and increase irrigation uses by 69,000 acre-feet, primarily in the Upper Main Stem subregion.

New Mexico water depletions would increase 228,900 acre-feet, primarily for electric power, irrigation, and export to the Rio Grande Basin.

Additional developments in Utah would all occur in the period 2001-2020. Irrigation projects not previously incorporated in plans would require over 200,000 acre-feet of water; coal conversion would double and require 22,300 acre-feet more water; and a 100,000 addition would be exported to the Great Basin Region.

Projected depletions of the Colorado River system by Wyoming total 1,588,000 acre-feet, which is 545,000 acre-feet more than at the 8.16 MAF level of development. Increases in depletions occur primarily in mineral production and export.

Table 58 lists the projected irrigated acreages under this alternative.

Table 57 - Water use for the States' alternative for water available at site, Upper Colorado Region

Type of use	On-site depletions (acre-feet per year)								
	Arizona	Colorado	New Mexico	Utah	Wyoming	Region	Green River	Upper Main Stem	San Juan-Colorado
				- - 1980 - -					
Municipal and industrial	2,900	22,100	7,200	10,100	10,500	52,800	18,400	16,200	18,200
Electric power (thermal)	34,100	10,700	112,000	125,400	22,000	304,200	45,500	1,600	257,100
Minerals	400	19,500	11,800	10,300	48,900	90,900	61,400	13,700	15,800
Fish and wildlife	1,200	38,800	6,800	22,200	20,100	89,100	50,700	7,900	30,500
Recreation	100	700	100	1,000	200	2,100	800	700	600
Stockpond evaporation and livestock use	1,400	25,000	2,900	7,300	4,800	41,400	15,300	13,700	12,400
Subtotal	40,100	116,800	140,800	176,300	106,500	580,500	192,100	53,800	334,600
Irrigation: consumptive use, incidental and reservoir evaporation	7,000	1,391,100	245,000	576,600	431,500	2,651,200	1,032,900	1,007,800	610,500
Export		663,400	118,000	190,000	115,000	1,086,400	305,000	660,900	120,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	47,100	2,171,300	503,800	940,300	653,000	4,315,500	1,530,000	1,722,500	1,063,000
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 1980						4,975,500	1,597,000	1,739,500	1,639,000
				- - 2000 - -					
Municipal and industrial	4,800	50,000	13,600	20,200	19,300	107,900	41,500	31,900	34,500
Electric power (thermal)	34,100	153,200	131,000	291,800	37,000	647,100	234,400	61,600	351,100
Minerals	300	128,300	17,400	10,700	140,100	296,800	192,600	67,700	36,500
Fish and wildlife	1,200	39,400	6,800	22,200	20,100	89,700	50,800	8,400	30,500
Recreation	300	1,100	100	1,600	200	3,300	1,400	900	1,000
Stockpond evaporation and livestock use	1,700	30,500	3,300	9,000	5,800	50,300	18,200	17,100	15,000
Subtotal	42,400	402,500	172,200	355,500	222,500	1,195,100	538,900	187,600	468,600
Irrigation: consumptive use, incidental and reservoir evaporation	7,600	1,792,500	491,000	660,600	534,500	3,486,200	1,325,000	1,19[illegible],800	962,400
Export		925,400	243,000	437,000	300,000	1,905,400	777,000	88[illegible],900	245,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	3,120,400	906,200	1,450,500	1,057,000	6,584,100	2,640,900	2,269,300	1,673,900
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2000						7,244,100	2,707,900	2,286,300	2,249,900
				- - 2020 - -					
Municipal and industrial	7,200	84,100	29,100	42,500	38,900	201,800	88,300	54,400	59,100
Electric power (thermal)	30,100	153,200	131,000	291,800	148,700	754,800	346,100	61,600	347,100
Minerals	300	207,500	32,500	187,900	307,700	735,900	571,900	113,300	50,700
Fish and wildlife	1,200	71,400	6,800	22,200	20,100	121,700	50,800	40,400	30,500
Recreation	400	1,600	200	2,600	400	5,200	2,200	1,300	1,700
Stockpond evaporation and livestock use	1,800	35,800	4,000	10,700	6,700	59,000	21,200	20,600	17,200
Subtotal	41,000	553,600	203,600	557,700	522,500	1,878,400	1,080,500	291,600	506,300
Irrigation: consumptive use, incidental and reservoir evaporation	9,000	2,010,500	571,000	935,500	562,500	4,088,500	1,550,900	1,385,600	1,152,000
Export		1,473,400	293,000	547,000	503,000	2,816,400	1,090,000	1,418,900	307,500
Less import				(-)2,600		(-)2,600			(-)2,600
Subtotal of all above	50,000	4,037,500	1,067,600	2,037,600	1,588,000	8,780,700	3,721,400	3,096,100	1,963,200
Main-stem reservoir evaporation						660,000	67,000	17,000	576,000
Total for 2020						9,440,700	3,788,400	3,113,100	2,539,200

Table 58 - Projected irrigated acreage for states' alternative for water available at site, Upper Colorado Region

Hydrologic Subregion and State	Irrigated land (1,000 acres) 1980	2000	2020
Green River			
Colorado	129.3	192.2	217.4
Utah	286.8	295.7	366.8
Wyoming	421.3	494.8	513.3
Subtotal	837.4	982.7	1,097.5
Upper Main Stem			
Colorado	646.4	727.2	810.9
Utah	9.6	9.7	35.4
Subtotal	656.0	736.9	846.3
San Juan-Colorado			
Arizona	10.0	9.4	9.4
Colorado	209.7	255.0	267.1
New Mexico	104.2	209.2	244.2
Utah	54.4	65.7	114.3
Subtotal	378.3	539.2	635.0
Region			
Arizona	10.0	9.4	9.4
Colorado	985.4	1,174.4	1,295.4
New Mexico	104.2	209.2	244.2
Utah	350.8	371.1	516.5
Wyoming	421.3	494.8	513.3
Total	1,871.7	2,258.9	2,578.8

PART VII

COMPARISONS AND CONCLUSIONS

Five levels of development are defined and evaluated in this study, i.e.:

Present (1965) level.
Regionally interpreted OBERS.
States' alternative - 6.5 million acre-feet.
States' alternative - 8.16 million acre-feet.
States' alternative - water supply available at site.

The framework plan, based upon the regionally interpreted OBERS projection, was developed first and was used as the basis and cornerstone for other studies. Three "states' alternatives" or choices were developed to reflect capability of the region to supply goods and services not fully evaluated in the OBERS projections. The 1968 OBERS and the on-going programs were also studied and will be discussed.

The effect of the various levels of development on water and related land resources and economic and agricultural activity, as well as conclusions reached, are presented in this section.

Comparisons

Water supply

Average annual historical discharge at the principal measuring point for the Colorado River, at Lee Ferry, Arizona, averaged 12,426,000 acre-feet for the 52-year period, 1914 through 1965. Because of variations in precipitation and other climatic influences, the extremes were 21,894,000 acre-feet in 1917 and 4,396,000 acre-feet in 1934. For the same period, average annual virgin or undepleted flow, as it would have been without man's influences, would have averaged 14,870,000 acre-feet.

The future outflow at Lee Ferry will depend on which level of development actually occurs, as well as augmentation. Augmentation practices considered as possibilities include water-yield improvement and weather modification which may increase the supply by about 1 to 2 million acre-feet.

Augmentation will definitely be required by 2020 for the two highest levels of depletion to meet Colorado River Compact apportionment to the lower basin. Local shortages in the region may occur at any level of development.

On-site water depletions

Four projected levels of depletion for alternative resource development are shown in Table 59. The present base of 1965 is used as a reference for projections. Data in Table 59 compares the on-site depletions of the four projected levels of development for the year 1965 and for the year 2020. Depletions are shown by type of use, states, and subregions. Depletions are estimated to nearly double from the present 1965 level to the level of the framework plan in 2020 and states' alternative at the 6.5 million acre-foot level. Irrigation depletions and export, which will account for about 75 percent of total depletions, will each increase about a million acre-feet. Thermal-electric power uses will have the greatest percent of increase--at the 8.16 MAF level of development about 3,000 percent.

Water for mineral uses will increase significantly with oil shale development being included in the three "states' alternatives." For comparative purposes the alternative at 6.5 MAF was defined by the states at the same total depletion level in 2020 as the framework plan. Departure from the framework plan due to states' adjustment in types of use is shown in Table 60. Two additional states' alternatives for greater depletion levels were then defined. Departure from the framework plan due to states' adjustment in type of use for the 8.16 MAF level of depletion is shown in Table 61.

Agricultural activity

Agriculture in this region is tied to irrigated cropland production. Therefore, the increase in production on existing irrigated lands and the development of new irrigated land relates to a large portion of the agricultural activity. (See Table 62.) Projected irrigated acreage for the alternative levels of development by time frame, is as follows:

Level of development	Irrigated acreage (thousand acres)			
	1965	1980	2000	2020
On-going program	1,622	1,732	1,878	2,024
1968 OBERS	1,622	1,499	1,529	1,551
Regionally interpreted OBERS	1,622	1,794	1,954	2,122
States' alternative (6.5 MAF)	1,622	1,792	2,102	2,118
States' alternative (8.16 MAF)	1,622	1,872	2,224	2,354
States' alternative (water available)	1,622	1,872	2,259	2,579

The on-going program is based on installation of authorized Federal projects and development of new irrigated land by private interests. About 70 to 80 percent of the present lands having short water supply

Table 59 - Summary of water resources development, Upper Colorado Region

	Level of Development				
			States' alternatives		
	1965	Regionally Interpreted OBERS Year 2020	6.5 Million Acre-feet Year 2020	8.16 Million Acre-feet Year 2020	Water Available At Site Year 2020
			(Acre-feet)		
VIRGIN WATER SUPPLY (1914-65)	14,872,000	14,872,000	14,872,000	14,872,000	14,872,000
ON SITE WATER DEPLETIONS					
By type of use					
Municipal and industrial	27,400	110,100	147,600	191,800	201,800
Electric power (thermal)	23,200	626,600	604,400	713,800	754,800
Minerals	33,700	52,800	231,700	550,100	735,900
Fish and wildlife	11,700	87,800	88,400	121,700	121,700
Recreation	1,300	5,200	5,200	5,200	5,200
Stockpond evaporation and livestock use	34,900	59,000	59,000	59,000	59,000
Subtotal	132,200	941,500	1,136,300	1,641,600	1,878,400
Irrigation	2,127,800	3,294,000	3,296,800	3,657,700	4,088,500
Export	550,300	1,652,500	1,454,900	2,203,300	2,816,400
Less import	(-)2,600	(-)2,600	(-)2,600	(-)2,600	(-)2,600
Subtotal of all above	2,807,700	5,885,400	5,885,400	7,500,000	8,780,700
Main Stem Reservoir evaporation	643,000	660,000	660,000	660,000	660,000
Total	3,450,700	6,545,400	6,545,400	8,160,000	9,440,700
By state					
Arizona	10,100	50,000	50,000	50,000	50,000
Colorado	1,706,600	3,009,800	3,019,400	3,855,400	4,037,500
New Mexico	144,900	666,200	656,700	838,100	1,067,600
Utah	664,000	1,341,100	1,341,900	1,713,500	2,037,600
Wyoming	282,100	818,300	817,400	1,043,000	1,588,000
Total	2,807,700	5,885,400	5,885,400	7,500,000	8,780,700
By subregion					
Green River	1,059,500	2,385,100	2,328,300	3,040,300	3,788,400
Upper Main Stem	1,397,300	2,245,200	2,232,500	2,877,000	3,113,100
San Juan-Colorado	993,900	1,915,100	1,984,600	2,242,700	2,539,200
Total	3,450,700	6,545,400	6,545,400	8,160,000	9,440,700
OUTFLOW	11,421,300	8,326,600	8,326,600	6,712,000	5,431,300

Table 60.--Departure from framework plan due to states' adjustment in types of uses (6.5 MAF level of development in year 2020)

Type of use by Sub-basin	Arizona		Colorado		New Mexico		Utah		Wyoming		Total	
	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet
Thermal Electric Power (Megawatts)												
Green River	-	-	-10,700	-161,300	-	-	+6,600	+98,900	-	-	-4,100	+62,400
Upper Main Stem	-	-	-490	-7,600	-	-	-	-	-	-	-490	-7,600
San Juan-Colorado	-	-	+1,500	+22,500	-1,500	-51,200	+5,100	+76,500	-	-	+5,100	+47,800
Total	-	-	-9,690	-146,400	-1,500	-51,200	+11,700	+175,400	-	-	+510	-22,200
Oil Shale Development (Barrels per day)												
Green River	-	-	-	-	-	-	+500,000	+41,500	-	-	+500,000	+41,500
Upper Main Stem	-	-	+1,000,000	+83,000	-	-	-	-	-	-	+1,000,000	+83,000
San Juan-Colorado	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	+1,000,000	+83,000	-	-	+500,000	+41,500	-	-	+1,500,000	+124,500
Potash Development (Tons per year)												
Green River	-	-	-	-	-	-	-	-	-	-	-	-
Upper Main Stem	-	-	+1,500,000	+9,500	-	-	-	-	-	-	+1,500,000	+9,500
San Juan-Colorado	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	+1,500,000	+9,500	-	-	-	-	-	-	+1,500,000	+9,500
Coal By-products and General Minerals												
Green River	-	-	-	-	-	-	-	-	-	-	-	-
Upper Main Stem	-	-	-	-	-	-	-	-	-	-	-	-
San Juan-Colorado	-	-	(Unidentified)	+15,000	(Unidentified)	+29,900	-	-	-	-	(Unidentified)	+44,900
Total	-	-	"	+15,000	"	+29,900	-	-	-	-	"	+44,900
Municipal and Industrial (Population)												
Green River	-	-	-	-	-	-	+53,500	+9,200	-	-	+53,500	+9,200
Upper Main Stem	-	-	+78,000	+14,000	-	-	-	-	-	-	+78,000	+14,000
San Juan-Colorado	-	-	-	-	+64,500	+11,800	+11,500	+2,500	-	-	+76,000	+14,300
Total	-	-	+78,000	+14,000	+64,500	+11,800	+65,000	+11,700	-	-	+207,500	+37,500
Irrigated Land (Acres)												
Green River	-	-	+58,300	+111,600	-	-	+9,000	-4,400	(-supplemental)	-900	+67,300	+106,300
Upper Main Stem	-	-	-39,000	-66,700	-	-	+1,700	+200	-	-	-37,300	-66,500
San Juan-Colorado	-	-	-12,800	-13,400	-	-	-21,200	-23,600	-	-	-34,000	-37,000
Total	-	-	+6,500	+31,500	-	-	-10,500	-27,800	-	-900	-4,000	+2,800
Exports (Acre-feet)												
Green River	-	-	-	-	-	-	-	-200,000	-	-	-	-200,000
Upper Main Stem	-	-	-	+2,400	-	-	-	-	-	-	-	+2,400
San Juan-Colorado	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	+2,400	-	-	-	-200,000	-	-	-	-197,600
Fish and Wildlife												
Green River	-	-	-	+100	-	-	-	-	-	-	-	+100
Upper Main Stem	-	-	-	+500	-	-	-	-	-	-	-	+500
San Juan-Colorado	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	+600	-	-	-	-	-	-	-	+600
Grand Total	-	-	-	+9,600	-	-9,500	-	+800	-	-900	-	0

Table 61.--Departure from the framework plan due to states' adjustment in types of uses (8.16 MAF level of development in year 2020)

Type of use by Sub-basin	Arizona		Colorado		New Mexico		Utah		Wyoming		Total	
	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet	Units	Acre-feet
Thermal Electric Power (Megawatts)												
Green River	-	-	-10,000	-161,300	-	-	+7,600	+113,900	-	-	-3,100	-47,400
Upper Main Stem	-	-	+2,510	+37,400	-	-	-	-	-	-	+2,510	+37,400
San Juan-Colorado	-	-	+1,500	+22,500	-1,500	-16,800	+6,100	+91,500	-	-	+6,100	+97,200
Total	-	-	-6,690	-101,400	-1,500	-16,800	+13,700	+205,400	-	-	+5,510	+87,200
Oil Shale Development (Barrels per day)												
Green River	-	-	+1,000,000	+83,000	-	-	+1,000,000	+83,000	+1,000,000	+83,000	+3,000,000	+249,000
Upper Main Stem	-	-	+1,000,000	+83,000	-	-	-	-	-	-	+1,000,000	+83,000
San Juan-Colorado	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	+2,000,000	+166,000	-	-	+1,000,000	+83,000	+1,000,000	+83,000	+4,000,000	+332,000
Potash Development (Tons per year)												
Green River	-	-	-	-	-	-	-	-	-	-	-	-
Upper Main Stem	-	-	+1,500,000	+9,500	-	-	-	-	-	-	+1,500,000	+9,500
San Juan-Colorado	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	+1,500,000	+9,500	-	-	-	-	-	-	+1,500,000	+9,500
Coal By-products and General Minerals												
Green River	-	-	-	-	-	-	(Unidentified)	+71,000	(Unidentified)	+18,200	(Unidentified)	+89,200
Upper Main Stem	-	-	-	-	-	-	-	-	-	-	-	-
San Juan-Colorado	-	-	(Unidentified)	+15,000	(Unidentified)	+51,400	"	+200	-	-	"	+66,600
Total	-	-	"	+15,000	"	+51,400	"	+71,200	"	+18,200	"	+155,800
Municipal and Industrial (Population)												
Green River	-	-	+78,000	+14,100	-	-	+101,000	+18,100	+110,000	+19,700	+289,000	+51,900
Upper Main Stem	-	-	+78,000	+14,000	-	-	-	-	-	-	+78,000	+14,000
San Juan-Colorado	-	-	-	-	+64,500	+11,800	+23,000	+4,000	-	-	+87,500	+15,800
Total	-	-	+156,000	+28,100	+64,500	+11,800	+124,000	+22,100	+110,000	+19,700	+454,500	+81,700
Irrigated Land (Acres)												
Green River	-	-	+82,500	+177,900	-	-	+7,100	+10,700	+120,800	+134,500	+210,400	+323,100
Upper Main Stem	-	-	+14,600	+29,600	-	-	-	-	-	-	+14,600	+29,600
San Juan-Colorado	-	-	+7,300	+11,000	-	-	-	-	-	-	+7,300	+11,000
Total	-	-	+104,400	+218,500	-	-	+7,100	+10,700	+120,800	+134,500	+232,300	+363,700
Exports (Acre-feet)												
Green River	-	-	-	+40,000	-	-	-	-20,000	-	-32,000	-	-12,000
Upper Main Stem	-	-	-	+425,800	-	-	-	-	-	-	-	+425,800
San Juan-Colorado	-	-	-	+11,500	-	+125,500	-	-	-	-	-	+137,000
Total	-	-	-	+477,300	-	+125,500	-	-20,000	-	-32,000	-	+550,800
Fish and Wildlife												
Green River	-	-	-	+100	-	-	-	-	-	+1,300	-	+1,400
Upper Main Stem	-	-	-	+32,500	-	-	-	-	-	-	-	+32,500
San Juan-Colorado	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	+32,600	-	-	-	-	-	+1,300	-	+33,900
Grand Total	-	-	-	+845,600	-	+171,900	-	+372,400	-	+224,700	-	+1,614,600

Table 62 - Comparisons of selected agricultural and industrial activity at five alternative levels of development
Upper Colorado Region

Type of production	Units	1965 base	Frame-work plan in 2020	States' alternatives: 6.5 million acre-feet in 2020	States' alternatives: 8.16 million acre-feet in 2020	States' alternatives: Water available at site in 2020
Agricultural Activity						
Irrigated land	1,000 acres	1,622	2,122	2,118	2,354	2,579
Dry cropland	1,000 acres	603	503	503	503	503
Range grazing production	1,000 AUM's	6,368	7,665	7,665	7,665	8,392
Timber production	Mil. cu. ft.	48	340	340	340	340
Industrial Activity						
Electric power						
Thermal	Megawatts	1,335	42,081	42,591	47,591	50,391
Hydro	Megawatts	1,300	1,300	1,300	1,300	1,300
Minerals						
Shale oil	Mil. bbl/day	0	0	1.5	4	4
Coal byproducts	Equivalent mil. bbl./day	0	0	0.2	0.8	1.6
Potash	Tons/day	0	0	4,100	4,100	4,100
Fish and Wildlife - Recreation						
Fish and wildlife						
Sport hunting	1,000 man-days	1,268	2,374	2,634	2,955	3,072
Sport fishing	1,000 man-days	3,547	8,667	9,221	9,691	10,094
Recreation	Mil. rec.-days	56	225	225	225	225
Watershed Management and Flood Control						
Watershed management						
Sediment yield reduction	Ac.-ft./yr.		2,764	2,764	2,764	2,764
Flood Control						
Flood damage reduction	1,000 dollars		6,744	7,063	7,754	
Economic Activity (Economic Boundaries)						
Population	1,000's	337	660	746	901	
Employment	1,000's	111	251	285	343	
Gross regional product	Mil. dollars	1,142	10,470	11,712	13,906	
Personal income	Mil. dollars	730	7,572	8,570	10,529	

will receive supplemental water in connection with new land development, except for the 1968 OBERS alternative. It is assumed in the 1968 OBERS level that agricultural activity will increase only by importing feed and feeder calves for projected feedlot operations.

Timber production under on-going programs will increase about 5 percent in each time frame of the projected period. The 1968 OBERS timber production shows an increase of four times the present production by 2020. For the framework plan and the three states' alternatives, production will increase about sevenfold over the present.

Livestock grazing production under on-going programs is estimated to increase only 0.3 million AUM's by 2020. The 1968 OBERS projections would require a reduction in going programs with a resultant waste of the resource. The framework plan shows an increase of 1.3 million AUM's. Optimum grazing production would provide an increase of over 2 million AUM's. This production is available as an alternative for the framework plan and the three states' alternatives. In Table 62 it is shown only under the "water at site" level of development, because grazing is not affected by the alternative water supplies analyzed under the other two states' alternatives.

Industrial activity

Two significant sectors of industrial activity in the region are production of minerals and thermal-electric power. Thermal-electric power capacity installed to supply local use and for export would increase from the present 1,300 to 47,600 megawatts at the highest level of development. Mineral activity planned for the states' alternative levels includes four shale oil plants with a total capacity of 4 million barrels-per-day. Coal conversion by hydrogenation is planned. This, together with coal mined for thermal-power production, approximates 200 million tons annually. Uranium production will increase significantly. Trona production in Wyoming is projected to increase to four times the present level.

Fish and wildlife - recreation

Present sport hunting and fishing demand is projected to nearly double by 2020 under both the on-going and the framework plan. Alternative plans are based upon projected population changes. Recreation demand, 97 percent by nonresidents, will increase fourfold.

Watershed management

Watershed management is planned to correct the average annual damages shown in Table 18. The program is shown in Tables 39 and 40. This program also includes improving water yield in terms of quantity, quality

and timing as a result of the vegetal manipulation. The going program will accomplish about 40 percent of the framework plan.

No alternative levels of damage reduction are included for the states' alternatives because programs such as oil shale development are planned to include the necessary watershed protection measures as a part of the development cost itself. The increased population under alternative levels and resultant impact on the watershed may increase the cost of accomplishing the planned protection. Adequate data to estimate the costs are not available.

Flood control

One basic plan has been prepared for flood control. However, flood damage and damage reduction have been evaluated for two alternative levels of development. A comparison of estimated average annual flood damages (1965 prices and project conditions) under the framework plan and the alternative projections, exclusive of "water available at site," follows:

Estimated average annual flood damage
(thousands of dollars)

		States' alternative	
1965	Framework plan in 2020	6.5 million acre-feet in 2020	8.16 million acre-feet in 2020
2,792	10,600	10,900	11,900

The flood damage reduction under these alternative levels of development is shown in Table 62.

Economic activity

Comparisons of population, employment, gross regional product, and personal income are shown in Table 62.

Costs

Cost data have previously been presented in Tables 45-49, inclusive, for water development and associated development programs for the framework plan. Average annual expenditures for water development during the 5-year period 1965-69 were also compiled from agency and state reports. Comparison of these data is shown on the following page.

	Water development		Associated development	
	Federal	Non-Federal	Federal	Non-Federal
	(thousands of dollars)			
1965-69 average annual installation	54,880	16,000		
OM&R	10,000	1,250		
Framework plan average annual installation				
1966-1980	62,420	16,930	12,820	167,240
1981-2000	34,950	18,740	15,410	283,730
2001-2020	19,410	13,530	22,490	47,400
Increased annual OM&R (at end of period)				
1966-1980	5,010	12,530	14,610	201,340
1981-2000	2,470	17,820	10,990	441,790
2001-2020	2,070	7,370	12,770	-34,490

The large expenditures for the associated development program are primarily designated for the acquisition and development of recreational land and facilities and the installation and operation of thermal-electric generating plants.

The 1965-69 figures represent the average in a period of declining Federal expenditures. Compared to the $64.9 million average, 1966 estimates showed $76.0 million and 1969 $47.6 million. Non-Federal expenditures remained at about the same level during the 1965-69 period.

Conclusions

The framework plan as outlined is general in nature and presents one way in which the region's water and related land resources can be developed and utilized to meet projected demands through the year 2020. Three states' alternative plans were formulated to reflect the capacity of the region to utilize resources and to supply goods and services not required under the framework plan.

While the plan and the alternative levels of development were not studied in sufficient depth to identify alternative means of meeting needs and outline specific programs and projects, they satisfy the objectives of delineating the adequacy of the region's resources. The plans also identify associated problems and considerations in relation to conserving the resources and to providing for the overall well-being of people.

The framework plan generally meets all needs and demands of the regionally interpreted OBERS projections. The three "states' alternative"

plans also generally meet the regionally interpeted OBERS needs and demands plus additional needs associated with higher levels of development.

Natural resources are available to meet all needs except for part of the water-related recreation demand imposed by the projected heavy nonresident activities and shortages resulting from localized hunting and fishing pressures. The programs of watershed management and flood control do not provide full treatment and protection due to economic considerations. Although ample resources have been identified to meet the other projected needs, there are conflicting land and water uses which remain unresolved. Additional studies are needed to identify and weigh alternative developments. Land use studies are needed to identify areas which should be preserved and to designate the prime use of areas where resource availability overlaps. State water plans are under various stages of preparation along with Federal and private water development investigations. Completion of these and additional studies appear necessary to give a basis for selecting developments which will be in the best public interest.

Expenditures would have to be increased substantially, particularly by the Federal Government, to accomplish the $2.9 billion water-related programs under the framework plan. Very large expenditures would also be required by non-Federal interests to provide for installation of the $7.6 billion electric power facilities and the acquisition of lands for the $3.2 billion recreation program under the total framework plan.

Legal and institutional

Legal and institutional arrangements now provide broad and complex systems for the development and administration of the land and water resources of the region. The arrangements provided by state and Federal laws are largely complementary and have produced a high degree of cooperation. However, challenges and conflicts have arisen and still exist within the Upper Colorado Region and in the relationships with adjacent regions. The principal problems requiring solutions or adjustments are centered in the field of reserved water rights, interpretations of the compacts regulating the use of the water of the Colorado River system, water pollution, land use, and environmental considerations. Further legal remedies will be sought as water resources development approaches the limit of available supplies.

Economic activity

Economic development restraints imposed by the relatively large distance to major population centers and markets, the small population base and other factors are expected to continue to restrict development of many of the region's resources. Although total gross output is expected to increase from about $0.5 billion in 1965 to about $3 billion in 2020, this merely maintains the relative position of the region in terms of the growth rate projected for the Nation.

Water supply

Sufficient water is physically available for on-site regional use and export to meet the needs projected by the regionally interpreted OBERS (6.55 million acre-feet) and the three states' alternatives at 6.55, 8.16, and 9.44 million acre-feet. However, augmentation of the Colorado River system water supply will be required to meet the higher development levels and downstream commitments. The exact quantity of augmentation cannot be determined because of varying interpretations of compacts and treaties which affect the Colorado River Basin water supply.

Land resources

Land resources exist in sufficient quantity to meet requirements of all projected levels of development. Potentially irrigable land over that used in 1965 totals 7.06 million acres. Selection from these lands can be made to meet irrigated land needs up to the 1 million additional acres projected under the largest alternative. Of the 60.4 million acres used for grazing in 1965, 5.8 million acres should be retired as they are unsuitable for continued grazing use. Placing of all remaining grazing lands on a sustained yield basis will provide for increasing forage production from 6.4 to 8.39 million animal unit months. The small total requirements for urban, industrial, transportation, utilities; developed recreation, fish and wildlife; and developed minerals can be selected as needed but will result in decreases in land available for grazing, timber production, and dry cropland.

Need will continue to select and preserve lands for wilderness, primitive, outstanding natural, historic, and cultural areas and scenic rivers. Management is required, under the multiple-use concept, of about 41 million acres for key habitat of wildlife. Nearly all lands are available for extensive use as undeveloped recreation and hunting areas.

Commercial timber exists on 9.4 million acres. Reduction in commercial forests of about 225,000 acres will result from conversion of forest lands to other uses. This will necessitate an intensified timber management and timber harvest program to achieve the required production--about seven times the present production.

Minerals

There is ample evidence to suggest that the resource base of the more important minerals customarily produced during the past two decades in the Upper Colorado Region is sufficient to meet all reasonable demands through 2020. The physical presence and production potential of such commodities as molybdenum, coal, and trona clearly fit this assumption. Oil, gas, and uranium are examples of minerals that appear to have a less favorable resource base. However, synthetic fuel potential from oil shale, rock asphalt, and coal offers alternatives that can relieve demand pressure on

conventional fuels. The on-coming development of the uranium breeder reactor, which would produce the fuel plutonium, would also replace conventional fuels.

Watershed management

If no additional watershed land treatment or flood protection programs are initiated, average annual damages will increase from the present $8.7 million to $25.6 million by 2020, assuming the framework plan level of development. Management and protection programs include land treatment on 24 million acres and installation of 78,000 water control structures. These will correct most of the existing problems that can be treated. Increased protection is an integral part of the future production activity. Cost of the erosion, flood, and sediment prevention and the water yield improvement programs in terms of average per-year expenditures for installation and operation, maintenance, and replacement for 1966 to 2020 is $24.4 million.

Erosion, the most significant problem affecting 30.5 million acres, requires an immediate action program to treat 3.9 million acres in critical erosion condition.

Watershed treatment programs needed to correct the treatable existing problems will be the same for all alternatives, and will be accomplished if funding is available. The "going program" based on 1964-69 level of development would accomplish about 78 percent of the proposed program. The additional protection needed for states' alternatives will be an integral part of the increased development cost.

Flood control

Without additional flood damage reduction measures, annual flood damage is estimated to increase from $2.8 million (1965) to approximately $4.2 million by 1980, $6.8 million by 2000, and $10.6 million by 2020. To reduce the hazards to health and human life and excessive economic losses from floods, an appropriate degree of protection should be provided through structural and nonstructural measures, consistent with other uses of water and land resources. The future flood damage reduction program consists of 0.2 million acre-feet of single-purpose flood control storage and 2.1 million acre-feet of multipurpose storage capacity; construction of 9 miles of levees and 11 miles of channel improvement; nonstructural measures including improved flood forecasting, dissemination of flood hazard information, flood plain zoning, and other measures by local authorities; and land treatment on 7 million acres under watershed management programs. The program would reduce potential annual flood damages by $6.7 million in the year 2020.

Recreation

Over 90 percent of the impact on recreation resources is estimated to result from nonresidents of the region. The low resident population, adjacent metropolitan areas, and high quality natural resources are the major factors that combine to create this situation. There is an abundance of undeveloped land available in public ownership to provide land-related recreation opportunities for residents and nonresidents. However, there are areas of outstanding quality not now in public ownership that need to be purchased to ensure their protection. Also, locally, there are needs for these lands because of inadequate distribution of public lands. To provide more people the opportunity to enjoy these areas, there is need for more recreation facility development and for supporting services. This need is related to private developments and to the presently inadequate funding and staffing of land administering agencies. Regionally, there are no surface water needs projected until 2020; however, there are needs locally because most of the water surface area is concentrated at a few locations. To make more existing and newly developed water areas available to recreationists, there is considerable need for more access. This may require legislation, special agreements, or the construction of more roads, as the case may warrant.

Fish and wildlife

Sport hunting and fishing capacity can continue to satisfy demands over future years with the exception of hunting and fishing in Arizona and New Mexico and the big-game hunting in Wyoming. Continued effective management will be essential and on-going plans and programs of the state and Federal fish and wildlife management agencies must be vigorously pursued to sustain the habitat capacity.

Electric power

A total power generating capacity installation of 43,400 megawatts is projected under the framework plan by the year 2000 to satisfy region and export requirements. This total includes a very large increase in thermal-electric generation facilities which will consume about 631,600 acre-feet of water annually for cooling purposes. No significant increase of hydroelectric plant installation is planned beyond those presently authorized or under construction. Pumped storage sites are available in the region but will not be developed soon as equally good sites are available at points closer to the large loads in adjacent regions. Generation by nuclear-fired plants or other methods is considered unlikely due to competition with lower cost coal fuel.

Water quality

The quality of surface and ground water supplies would generally decrease with the projected levels of use. However, the utility of water

in the region will not be seriously affected. Feasibility studies on potential water quality improvement projects for the Colorado River Basin are needed.